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UNIVERSITY OF ALBERTA

STRUCTURAL GEOLOGY

of the

LUSCAR-STERCO MYNHEER A ZONE,

COAL VALLEY, ALBERTA

by

© FREDERICK JOHN ALEXANDER, B.Sc.

A THESIS

SUBMITTED TO THE FACULTY OF GRADUATE STUDIES

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ABSTRACT

The Mynheer A zone of Luscar-Sterco Limited, in the Outer Foothills belt of the west-central Alberta Coal Branch area, contains an extensive pod formed in the lowermost or Mynheer seam of the Tertiary Coalspur coal measures. Although the zone has been mined over a period of 40 years, little published data on the area is available. Due to a lack of suitable data, the post-Wapiabi stratigraphy of the area is incomplete.

Based primarily upon recent preproduction exploration and development data, a study of the Mynheer A coal pod was undertaken to determine its geometry and structural setting. A series of 59 cross sections at 200 to 500 foot intervals along the length of the pod were constructed, together with structure contour maps of the top and bottom of the pod, and a coal pod isopach map, based on data from surface mapping and interpretation of a series of 372 geophysically logged boreholes. A surface geological map was also compiled.

The coal pod was found to be an elongate northwest-trending body parallel to regional strike, approximately 3 3/4 miles long by 200 to 1400 feet wide, and up to 300 feet thick where undisturbed by mining. It lies on

the common limb of the Coalspur anticlinorium to the northeast and the Lovett River syncline to the southwest, thinning to normal Mynheer seam dimensions to the northwest and terminating abruptly at the north-trending Reco Fault to the southeast. The shape of the pod increases in complexity southeastward from a simple thickened wedge in the northwest which increases in thickness toward the central third, where it is bounded on the northeast by a steep northeasterly-dipping fault and truncated at its apex by a shallow northeasterly-dipping thrust sheet; to the southeastern third, where the pod bifurcates into a main pod distorted by shallow overthrusting from the northeast, and an anticlinal secondary branch to the southwest.

Computer analysis of outcrop bedding orientations revealed two general structural regimes in the area, with slightly divergent, but southeasterly-trending shallow plunges.

ACKNOWLEGEMENTS

I am indebted to Luscar Limited for proposing the topic of this thesis and for their financial and technical support throughout the course of the project. In particular, I should like to thank chief geologist Keith Smith and David Mulder for their assistance and encouragement. I am also indebted to Eric Peterson and others of the drafting staff for their assistance in preparing the illustrations. The help of many others in the engineering and Coal Valley project staff is gratefully acknowleged, including the many fruitful discussions with Roy Pickett and Alan Clover of K. Wardell and Partners Limited of Birmingham, England, geotechnical consultants.

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1.0 Introduction

The Mynheer A zone is located in the Outer Foothills Coal Branch region of west central Alberta (see Figure 1). Centred on an extensive coal pod, the zone was in continuous production from 1918 to 1958, when mining ceased due to the loss of markets.

In 1970, Luscar Limited obtained an option on the leases comprising this area and others of the Sterling-Coal Valley Mining Company and incorporated Luscar-Sterco Limited with the view to rapid development and early production of thermal coal for the Ontario Market.

In spite of the long history of mining in the Coal Branch in general and in the Mynheer A zone in particular, little has been published in the way of detailed geology on this region. As far as can be determined, no detailed structural investigation of the Mynheer A zone has been carried out. As such a study is fundamental to the formulation and implementation of basic mine planning, the project was offered to the writer as a suitable thesis topic of practical application.

The purpose of this thesis is to present an interpretation of the available data on the Mynheer A zone, outlining the shape or geometry of the coal pod and its structural setting.

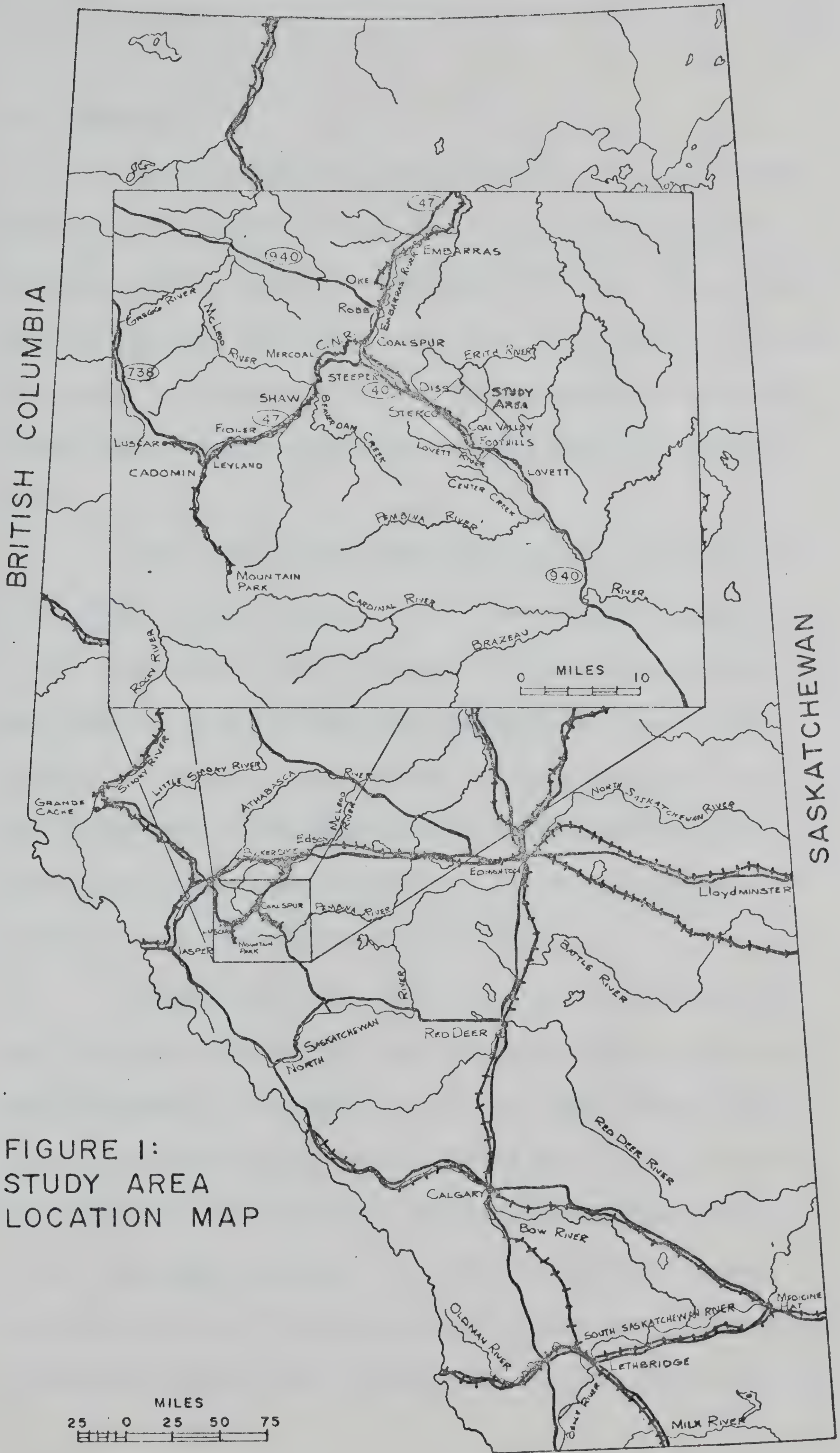

FIGURE 1:
STUDY AREA
LOCATION MAP

2.0 Preamble

While geological investigation in Alberta dates back at least to the work of Dr. A.R.C. Selwyn in 1873 (Dowling, 1909), specific examination of the central Alberta foothills did not take place until 1907, when D. B. Dowling began his explorations for the Geological Survey of Canada, and which he continued in 1909 (Dowling, 1908; 1910).

The value of the coalfields about the headwaters of the Embarras and Pembina Rivers was noted by Dowling in 1910, not particularly because of their grade, which was found to be relatively low compared to coals found farther to the west, but because of their proximity and ease of access to the Grand Trunk Pacific and Canadian Northern Railways then penetrating the Rocky Mountains through the Yellowhead Pass to the north.

Between 1906 and 1909, several discoveries of coal had been made in this area by prospectors including Donald McDonald, Bill Baillie and P.A. Robb (Ross, 1974). These discoveries led to the planning and construction of the famed Coal Branch by the Grand Trunk Pacific Railway to provide access to them. The Coal Branch was driven from Bickerdike on the main line 138 miles west of Edmonton to Coalspur, where the railway split into the West Arm

extending southwest to Luscar and then south to Mountain Park; and the East Arm, running southeast from Coalspur to Lovett. The line to Coalspur was completed in October 1912, and the East Arm completed to Lovett, or Fernie as it was sometimes known, in January, 1913. In 1919, the bankrupt Grand Trunk Pacific Railway and Canadian Northern Railway were taken over by the federal government and amalgamated into the Canadian National Railway (Ross, 1974).

Upon completion of the access railways, rapid development of the coal measures took place. Dowling revisited the Coal Branch in 1922, by which time most of the easily accessible coal seams of economic thickness were either being mined or prepared for development by a large number of mining companies. Three of the area mines were under development even before the lines were completed - at Mountain Park, Coalspur, and Lovett (Ross, 1974).

Because little was known of the geology of the area at this time, J.A. Allan and R.L. Rutherford spent the field seasons of 1922 and 1923, and Rutherford the summer of 1924, mapping the foothills belt from the North Saskatchewan River to the Athabasca River for the Scientific and Industrial Research Council of Alberta (Allan and Rutherford, 1923; 1924; Rutherford, 1925).

In 1943, B.R. Mackay published a map of the cent-

ral Alberta Foothills belt. Later, W.A. Bell, in 1945, undertook a paleobotanical study of the Mynheer seam at Sterco and Coalspur which was published in 1949. Since that time, little has been published on the geology of the study area, although a number of studies have been carried out in surrounding areas (Irish, 1965; Eliuk, 1969).

The development of Alberta coals, particularly those of the foothills and mountains was directly linked to the advance of the railways. Between 1900 and 1907, less than six million tons of coal were produced from Alberta mines (Draper, 1930). The railways, by introducing both a substantial market and a transport system, caused a tremendous surge in development. By 1924, some 399 mines were producing five million tons per year (Nordegg, 1930). A large proportion of these mines were small, inefficient and short-lived. By 1928, the number of mines was reduced to 281, but production had increased to over seven million tons per year (Nordegg, 1930). The railways formed the largest single market. By 1943, the two transcontinental railways alone consumed some 2,607,000 tons of western coal, the bulk of it being the low to medium volatile bituminous coals from the Inner Foothills. Lower rank coal from the Outer Foothills was also used in considerable quantities because of its relatively low cost,

mixed with the higher rank coals to fuel the locomotives (Carroll, 1947), and alone for heating purposes.

Both the Sterling Collieries Company operation at Sterco and the Foothills Coal Company mine at Foothills opened in 1918, followed by the Coal Valley Coal Company mine at Coal Valley three years later. The operations at Reco were under way by 1924 (Ross, 1974).

While the Reco mine was apparently a relatively small, short-lived operation, the Sterco, Coal Valley and Foothills mines were of moderately large size for the time. The Sterling Collieries Company Limited produced 1,905,306 tons of coal from 1930 to 1944, while the Coal Valley Coal Company produced 2,044,790 tons over the same period (Carroll, 1947), an average of 127,020 and 136,319 tons respectively. Their low mining costs, resulting from the use of steam shovels in excavating the coal from the Mynheer seam pod (Dowling, 1923), permitted both mines to declare substantial dividends during this period. As a contrast, the underground Foothills mine, despite a production of 913,000 tons from 1939 to 1944, required the injection of capital from government loans and subsidies to remain in production (Carroll, 1947).

The Sterling Collieries Company remained in operation until 1952, while the Coal Valley and Foothills

mines did not close until 1954 and 1958 respectively (Ross, 1974). Closure of the mines was due primarily to the loss of markets to the more convenient petroleum fuels, particularly by the railways, as substantial reserves of coal yet remain in the area (Luscar-Sterco Limited, 1975).

The increasing alarm over the dwindling reserves of petroleum since the early 1970's has brought about a resurgence in the interest in the thermal coals of western Canada. Higher costs and uncertainty of supply of petroleum fuels and the high capital investment involved in nuclear-electric generation with its by-product disposal problems, coupled with more advanced and cheaper transportation and handling methods, have made feasible the supply of central Canadian thermal-electric markets by western coals. On this basis, the area is being redeveloped by Luscar-Sterco Limited.

The study area (see Figure 2) includes not only the Mynheer A zone of Luscar-Sterco Limited, but also parts of their Mynheer Sterco Extension and Val D'Or Extension zones (Luscar-Sterco Limited, 1975). Within this area occur the abandoned coal-town sites of Sterco, Foothills, and Reco, and the site of the former town of Coal Valley, now for the most part abandoned, which served as the site of the Luscar-Sterco Limited field camp from 1970 to 1976.

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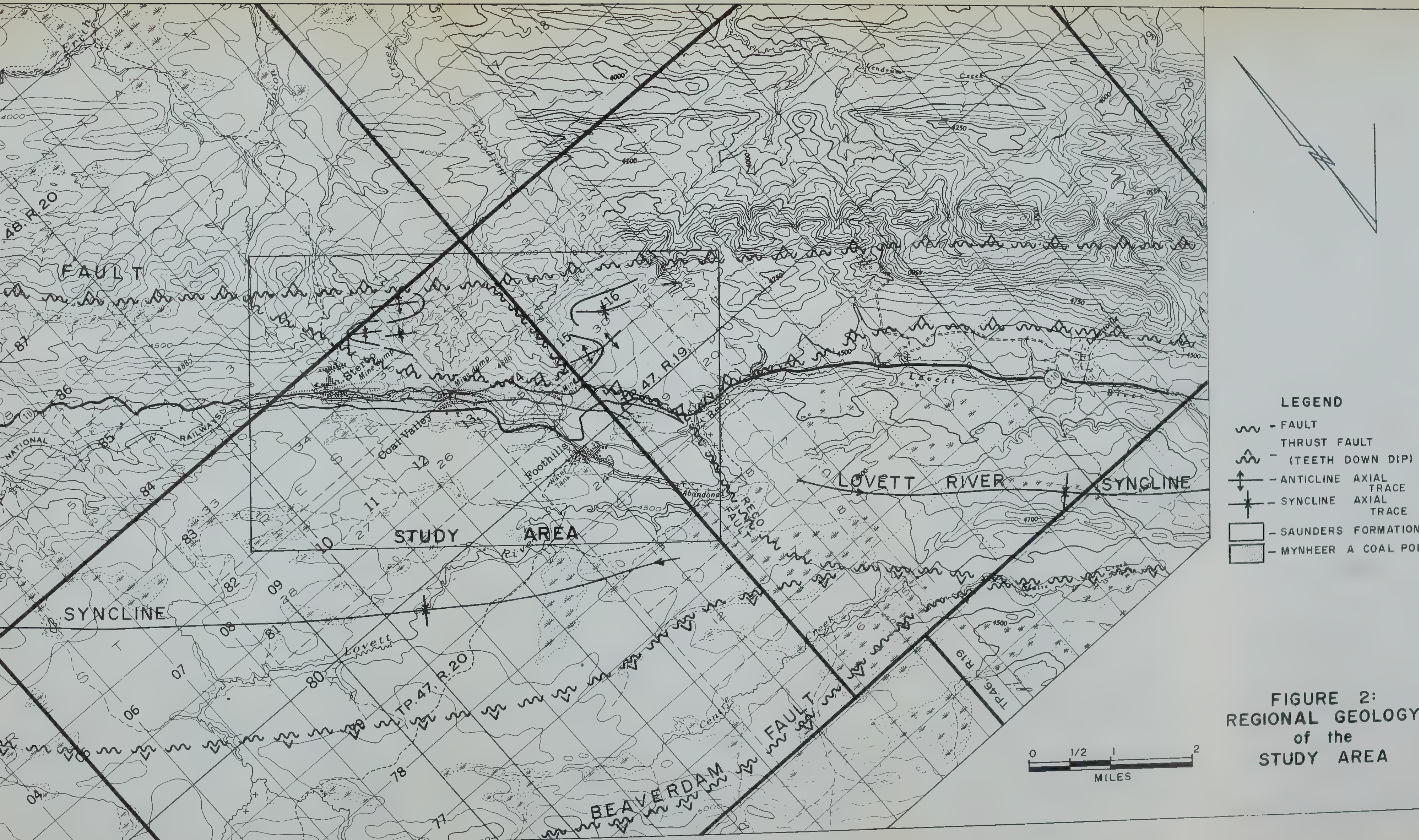


FIGURE 2:
REGIONAL GEOLOGY
of the
STUDY AREA

Access to the area is provided by the Forestry Trunk Road (Highways 40 and 940) via the town of Coalspur to the north and Nordegg to the south. Within the study area, access is provided by numerous mine and drill roads, and the generally northeast-southwest and northwest-southeast-trending network of seismic survey lines.

Railway access is available via the East Arm of the C.N.R. Coal Branch line parallel to Highway 40. This line, abandoned for more than 15 years, has been refurbished and now terminates approximately one mile southeast of the Foothills townsite.

The topography of much of the study area is characterized by the moderate relief typical of the Outer Foothills; the area to the northeast of the pod zone, however, is notably more rugged as a result of its greater structural complexity.

A feature of this area is the occurrence of the abandoned open pit mine workings of the Coal Valley Coal Company and Sterling Collieries Company. These comprise an area of open-cast pits and waste dumps nearly three and one-half miles long by three-quarters of a mile wide immediately northeast of Highway 40 at Coal Valley (see Figure 13).

The area lies in the Boreal Climatic Zone, and

is characterized by a predominantly lodgepole pine cover, with only rare white pine climax cover due to the frequent forest fires which have swept the area. The muskeg areas show a prevalence of black spruce, while on the ridges, frequent patches of poplar, alder thickets and rare stands of birch occur (Luscar-Sterco Limited, 1975).

Much of the area is blanketed by a variable thickness of up to several tens of feet of glacial till, and waste dumps and backfill cover much of the mine area to depths which in places exceed 150 feet. Frequent patches of muskeg occur, particularly in the southwestern and southeastern portions of the area, where the normal drainage pattern has been disrupted, principally by glaciation.

3.0 Geological Setting

Tectonic stress applied primarily during the Laramide orogeny developed a pattern of increasing structural complexity from east to west in a belt of varying width along the eastern side of the western Canadian cordillera. From the relatively undisturbed Alberta syncline, the structural pattern increases in complexity westward into the Outer Foothills, characterized generally by open folds and widely spaced thrusts, through the Inner Foothills with closer folding and more closely spaced thrusting, into the Front Ranges of the Rocky Mountains. A pattern of thrusting and upwarping of progressively older strata from east to west also occurs, ranging from the Paleocene beds of the Outer Foothills to the Paleozoic rocks exposed in the Front Ranges. A progressive westerly increase in rank and age of the coals exposed at the surface also occurs. In general, the progression is from non-caking, high volatile bituminous Tertiary coals of the Outer Foothills to the low and medium volatile bituminous, metallurgical Lower Cretaceous coals of the Inner Foothills.

The eastern portion of the Outer Foothills in which the thesis area occurs is characterized by several easterly-dipping, presumably shallow thrust faults (Link, 1954), approximately parallel to the regional strike of

about 135°. The most notable of these thrusts is the Lovett Fault (see Figure 2) traced by Allan and Rutherford from the Blackstone River to Coalspur (Allan and Rutherford, 1923; 1924: Rutherford, 1925). The trace of this thrust parallels the axial trace of the Coalspur anticlinorium. To the west, the broad, open Lovett River syncline occupies the area as far as the second major thrust - the westerly-dipping Beaverdam Fault. A predominantly north-trending, steeply-dipping to vertical fault passes just to the west of the Reco townsite, offsets the Lovett River syncline, and is in turn offset by a shallow, folded, northeasterly-dipping thrust extending southwestward from the Lovett Fault. The Coalspur coal measures occupy the common limb of the Coalspur anticlinorium and the Lovett River syncline to the southwest. Williams (1970a) considers the measures to be continuous across the Outer Foothills belt, cropping out on the northeastern limb of the Coalspur anticlinorium as the Robb trend, and on the southwestern limb of the Lovett River syncline as the Mercoal trend. From northwest of Sterco to just north of Reco, the lowermost Mynheer seam of the Coalspur coal measures has been thickened into a pod which in places is over 300 feet thick, and which is the focus of this study.

The Coalspur coal measures occur in the upper

part of a thick succession of non-marine clastic sediments overlying the middle to late Cretaceous marine clastics of the Wapiabi Formation. This accumulation consists of a more or less continuous succession of both laterally and vertically variable sandstones, shales, conglomerates and occasional coal seams and ash beds. Stratigraphic studies in the area have been severely hampered by the lack of marker horizons, paucity of fossils, structural deformation and poor exposure. Rutherford (1925) estimated the total thickness of these strata to be approximately 13,000 feet, while Williams (1970b) estimated the thickness in the immediate area to be from 5500 to 6000 feet on the basis of deep drill hole data. Because these are the uppermost consolidated sediments in the area, a variable and generally unknown amount has been lost to recent erosion.

This lack of concrete data has prevented the formulation of a definitive chronostratigraphic or lithologic stratigraphic column for the post-Wapiabi beds of the central foothills. No consensus has as yet been achieved for either the nomenclature or subdivision of this sedimentary sequence. Eliuk (1969) has presented a comprehensive analysis of the history and problems encountered in the stratigraphic studies carried out in the foothills relative to the included Entrance Conglomerate, estimated

to occur approximately 900 feet stratigraphically below the Mynheer seam.

While the persistent, widespread occurrence of this conglomerate is championed by Tozer (1956, p. 33), others, such as Rutherford (1947) and Williams (1970b), have some doubt that the conglomerate is as widespread or persistent as assumed. Entrance-type conglomerates are common throughout the succession, and are notably variable in both lateral and vertical extent. The coal seams of the Coalspur measures may be a more suitable horizon for stratigraphic division, as they are both definitive and can be traced over a wide area.

All post-Wapiabi beds below the Paskapoo Formation, which is also difficult to discriminate in this area, were considered to be Late Cretaceous in age until Bell (1949), on the basis of paleobotanical collections from the Mynheer seam at Sterco and Coalspur, concluded that the majority of the beds above the Entrance Conglomerate were in fact Paleocene in age. The Brazeau Formation, which previously included all strata between the Wapiabi and Paskapoo Formations, was then restricted to the post-Wapiabi strata below the Entrance Conglomerate. The latter was presumed to represent the Tertiary-Cretaceous systemic boundary, and succeeding beds were redefined as Paskapoo

(Tozer, 1956). Eliuk (1969), however, concluded on the basis of his microfloral study of the Entrance Conglomerate, that this horizon was in fact Maestrichtian (Latest Cretaceous) in age, and that the systemic boundary lies somewhere between it and a similar conglomerate of Paleocene age, but possibly older than type Paskapoo, some 3500 feet stratigraphically higher. If we accept the conclusions of Bell (1949) that the lowermost seam of the Coalspur coal measures is Paleocene in age, the systemic boundary must then occur within the 900 feet of strata separating the coal seam from the Entrance Conglomerate horizon.

For the purposes of this study, the coal measures and the enclosing strata are considered as Paleocene in age and will be referred to as Saunders Formation, following the precedent set by Allan and Rutherford (1924).

4.0 Stratigraphy

Whereas stratigraphic division is a subject of contention, it is generally conceded that a broad variation in sediment character exists in the succession of post-Wapiabi strata. The lower beds are usually light grey to greenish grey in color, and the sandstones are often coarser and harder, while the upper strata are usually shalier, softer and light brown to yellowish grey in color.

The sediments which crop out in the study area are predominantly medium grained, buff to light grey-brown, hard, massive to finely cross-bedded sandstones up to 80 feet thick. These sandstones occur along the tops of ridges because of their contrasting erosional resistance as compared to the generally much softer medium grey to greenish grey interstratified shales and siltstones. The sandstones are commonly given a "salt and pepper" texture by included carbonaceous and chert grains.

The cementing material of the sandstones is generally carbonate and/or authigenic clay. The "shales" or mudstones generally lack fissility and are frequently silty. Lenses of conglomerate, usually composed of well-rounded and frequently well-polished quartzite pebbles and cobbles in a matrix of relatively soft sandstone (see Plate VII) occur frequently in the succession. Trails of pebbles and

cobbles are frequently encountered within the sandstones, as are carbonized wood fragments. Occasional ash beds, such as those exposed on the northeast side of the coal pod about line 74+00, vary from very soft and sticky, white to olive green bentonite, to very hard and siliceous dark grey, white-weathering blocky tuffs. The ash beds are generally quite thin - a foot or less in thickness - but may be laterally persistent.

The Coalspur coal measures of the Sterco-Lovett area, consisting of four main seams named early in the mining history of the region, may be represented by the following generalized undisturbed section in descending order (see Figure 3):

Val D'Or Seam: Divided into a thin (2 to 5 feet) upper and a lower seam (about 8 to 20 feet thick) by a well defined sandstone parting 3 to 12 feet thick, the total coal interval varies up to 35 feet in thickness. The lower seam only was mined at Foothills.

Sediments: 60 to 80 feet of shales, sandstones and siltstones with minor coal seams.

Arbour Seam: Up to 16 feet thick, with two to three significant shale partings, this seam was never mined.

Sediments: 480 to 510 feet of thick sandstone, shale and siltstone, with occasional impersistent thin coal

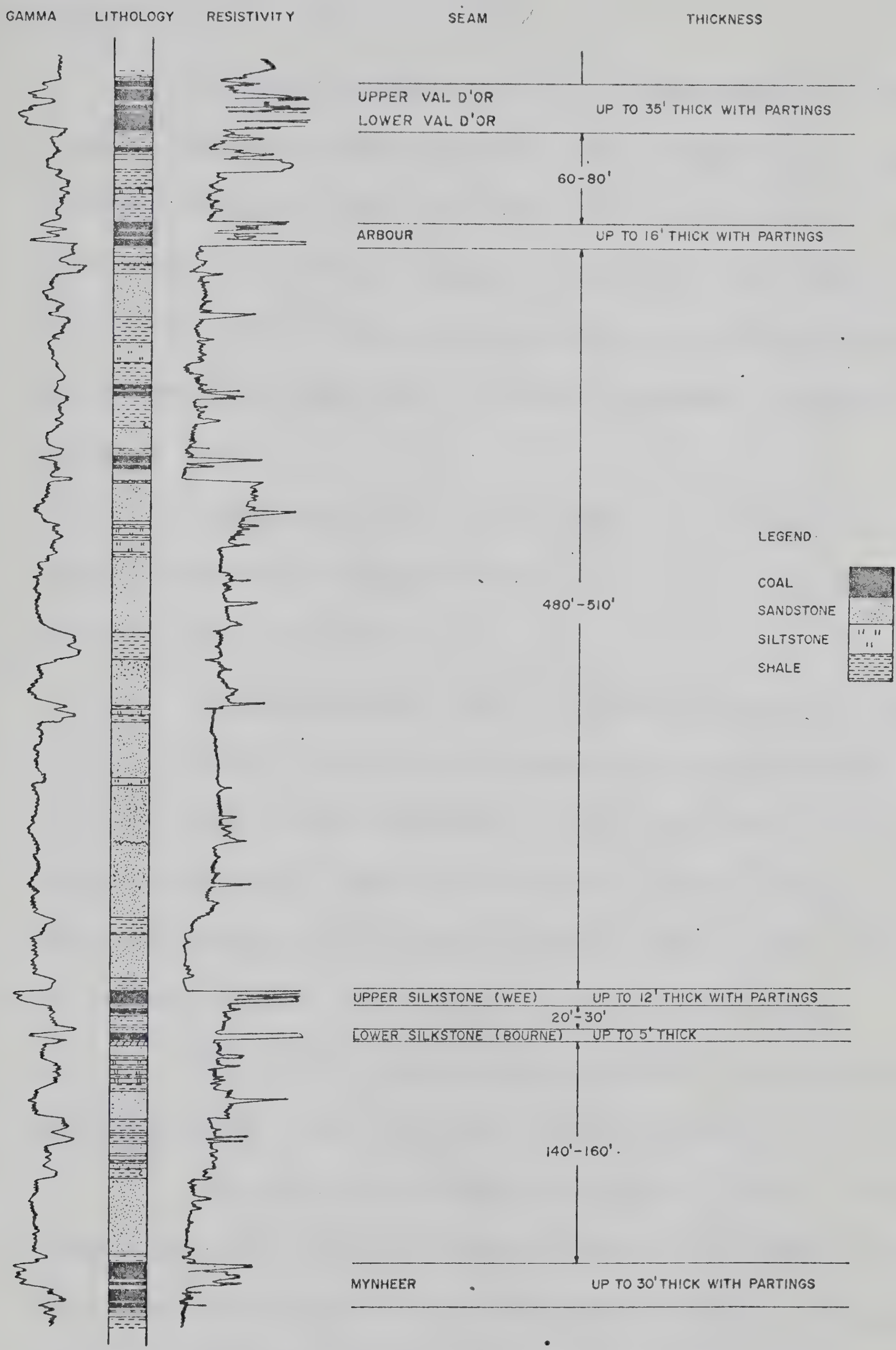


FIGURE 3: COALSPUR COAL MEASURES - Generalized undisturbed stratigraphic section

seams.

<u>Silkstone Seam</u>: Split in places by 20 to 30 feet of sandstone and siltstone into an upper (Wee) and a lower (Bourne) seam, this seam was mined at Lovett by the Pacific Pass Coal Company as early as 1913 (Ross, 1974). The upper seam is generally less than 12 feet thick with partings, while the lower reaches a maximum thickness of about 5 feet.

<u>Sediments</u>: 140 to 160 feet of sandstones, shales, and siltstones of variable thickness, with occasional thin impersistent coal seams.

<u>Mynheer Seam</u>: With a normal thickness of from 17 to 30 feet, including partings, the typical section is 23 feet thick, with the bottom 7 to 8 feet consisting of alternating coal, shale and bentonitic shale layers. This seam was extensively mined at Sterco, Coal Valley, Reco, and Lovett by both surface and underground methods.

The total stratigraphic interval included in the section varies generally from 700 to 900 feet.

The coal of the Mynheer A pod is closely fractured and sheared, and the normally uniform layering of the seam outside the pod zone is contorted, broken and imbricated by pseudoplastic deformation (see Plates I to VI). Despite such massive disturbance, a general tripartite ash

content (waste partings) zonation has been noted (D. Mulder, 1976 - personal communication) in which a zone of relatively clean coal is bordered above and below by lesser quality coal. This zonation is probably a product of both the original seam character and mechanical processes.

The results of one of the earliest proximate analyses of mine run coal from the study area are as follows (Stansfield et al., 1925):

Moisture	7.3%
Ash	10.2%
Volatile Matter	30.5%
Fixed Carbon	41.9%
B.T.U. Rating	9,730 (+230, -160)
Moisture (Air Dry)	6.1%
Sulphur	negligible

This analysis placed the coals into the non-coking sub-bituminous category of the time.

The Report of the Royal Commission on Coal (Carroll, 1947; p. 39) notes that the younger Tertiary coals of the Outer Foothills were largely in the category of high volatile C bituminous coal according to ASTM standard D338-38 (1937).

A more recent analysis examined the petrographic and chemical character of drill core samples from the Val

D'Or and Mynheer seams (Hacquebard and Birmingham, 1973). The Mynheer seam sample was taken to the southeast of the Mynheer A zone, from the Mynheer B area where the seam is relatively undisturbed. Microlithotype and maceral analyses were carried out on the coal intervals of the Mynheer seam through the use of 67 polished blocks and six grain mounts. From this, the seam was divided into ten petrographic intervals without including partings. An interpretation of the results of the analyses was given and is quoted as follows (Hacquebard and Birmingham, 1973; p. 11):

> "The variation in petrographic composition can be related to the type of peat development. As in the Val D'Or seam, forested peat bogs resulting in predominantly bright coal, high in reactive macerals, probably existed during the lower five intervals. Here also this part of the seam, which is 9 feet thick comprises the best coal. It has an average ash content of 13.5%, a B.T.U. value of 11,724 and contains two thin partings that are 4 and 5 inches thick.
>
> During interval VI a marked change took place in the environment of peat deposition. Due to a general rise in the groundwater table the arborescent vegetation was largely replaced by open pond and reed moor areas. The resultant coal is high in inertinite (particularly inertodetrinite [sic]) and in mineral matter. These conditions foreshadowed the 1'8" parting of coaly shale, which overlies interval VI.
>
> In the upper bench of the seam the position of the groundwater table remained relatively high, and coal that is in general similar to that of interval VI was laid down, but with less mineral matter (except for the roof coal, represented by interval X). The upper bench is 6 feet thick, has 15.4% ash and a B.T.U. value of 11,490. Its quality is some-

what less than that of the lower 9 foot bench."

Chemical analyses supported by reflectance studies showed that the coals of both seams belonged to the ASTM high volatile C bituminous category. The reflectance studies revealed a slightly higher metamorphic grade for the Mynheer seam as compared to the Val D'Or seam, probably the result of its lower stratigraphic position.

5.0 Borehole Data

Few data from the long mining history of the Sterling Collieries Company and Coal Valley Mining Company operations are available, and only a relatively meagre quantity of material has been published on the restricted area of this study. As a result, most of the study has been based on the work done in the area since 1969 for Luscar Limited and Luscar-Sterco Limited.

Since 1969, a large amount of information has been generated by the re-exploration and preliminary development of the area. Recent work includes aerial photography, photogeology, photogrammetric generation of topographic maps at 20 and 5 foot contour intervals (1"=1000' and 1"=200' scales), detail mapping of the pit areas on a 1"=200' scale on both geotechnical and geological bases, drilling programs, and a number of engineering, analytical, hydrological and ecological studies.

A period of about 20 days was spent in the field by the writer during June and July, 1976, for the purposes of re-examination of the outcrop areas already mapped, particularly in the mine pits, and in remapping an area of about one and one-half miles to each side of the pod zone. The mapping was accomplished through the use of the Luscar-Sterco Limited 1"=200' scale geological map of the pit area,

a 1"=1000' scale topographic contour map of the area, and 1"=1000' scale aerial photographs taken by Western Photogrammetry Limited in 1970. A significant number of previously undiscovered outcrops were examined, particularly in the topographically rugged area to the northeast of the pod zone centre.

A compilation of this work and previous mapping forms the base of the geological map of this thesis (see Figure 13). Although work continues in the zone to bring it up to production status, a data cutoff date of mid-August, 1976, was applied for the purpose of this thesis.

Many of the conclusions arrived at during the course of this study, particularly the shape of the coal pod, are based on data derived from the drilling programs carried out along the pod zone since 1970. Prior to the cutoff date, a total of 605 boreholes had been drilled in the zone. Of these holes, 372 were logged geophysically, and 24 cored. One hundred and eight of the geophysically logged holes were drilled in 1976. For 233 of the boreholes drilled in previous years, only drillers' logs are available.

In order to resolve some doubts as to the reliability of the drillers' logs, a simple statistical analysis of the correspondence between coal seam intersections as

noted on the drillers' reports and picked from the geophysical logs was undertaken on 161 boreholes. It was found that, despite surprising accuracy of within a few tenths of a foot in some holes, a significant degree of error exists, as can be seen in the following table:

Table I: Drillers' log reliability analysis

	Top Intersection	Bottom Intersection
No. of Boreholes:	161	127
Range of Deviation:	+36', -17.5'	+22', -38'
Mean Deviation:	+2.73'	-1.46'
Standard Deviation:	6.16'	7.90'

For the purposes of the analysis, the intersection deviation was defined as the depth to the first (or last) appearance of the coal pod in the drillers' logs minus the depth to the intersection picked from the geophysical logs. Positive values indicate that the drillers' log depth was below the geophysical log depth, and vice versa.

As a result of this analysis, drillers' logs were relegated to lowest priority in interpretive data. Drillers' logs were not summarily discarded, however, as they provided valuable corroborative data in interpreting

ambiguities in some geophysical logs.

Because the geophysical logs available were produced over a six and one-half year period (December, 1969 to August, 1976) by five different logging companies, some problems were experienced in correlation due to variation in sonde specification, log type, time constants (nuclear logs), logging speed and scales among the logs produced by the various companies. An unfortunate aggravating circumstance was that, except for the 1976 logs, only microfilm-derived photocopies of the logs were available, and these were often of rather poor quality.

The boreholes were normally 4½ to 4 3/4 inches in diameter and were drilled by self-contained mobile rotary rigs. The normal circulation fluid used was water, with bentonite and chemical muds used to boost circulation. Bran was used to control lost circulation. No readings of mud character were taken.

In general, the most frequently used log types were natural gamma (324), single-electrode resistivity - labelled as "Resistance" on the logs - (270), and gamma-gamma density (245). Less frequently used log types were neutron-neutron (54) and caliper (97). Normally, these logs were run in combinations of two or more. The 375 log sets used are broken down as follows:

Table II: Geophysical log combinations

Combination	Number
Gamma-resistivity-density	101
Gamma-resistivity	79
Gamma-resistivity/caliper-density	75
Gamma-neutron	48
Density	38
Caliper-density	15
Gamma-density	9
Gamma-resistivity/gamma-neutron/ caliper-density	5
Gamma-caliper-density	2
Gamma	2
Gamma-resistivity/gamma-neutron	1

The most valuable of the log combinations for the purposes of the study was found to be the natural gamma-resistivity/caliper-density combination, as emphasis was placed on the location and definition of the coal seams and general lithological determination of the enclosing strata.

All four of the above logs react to the intersection of coal in a borehole. Because coal is an organic material, its content of radioactive material is relatively

low except under extraordinary circumstances, thus the natural gamma log trace normally shows an anomalously low zone. Conversely, because of its strong insulating character, the resistivity curve typically shows an anomalously high value. The bulk density of coal is also much lower than that of the enclosing sediments (generally 1.5 to 1.6 gm/cc, compared to 2.3 gm/cc average for the enclosing rocks), thus a strong density anomaly is normally recorded across a seam intersection. Finally, the caliper tool often records an oversize hole across the coal intersection because of caving and mud erosion of the coal.

In spite of these strong reactions, no single log type will unequivocably define a coal intersection or more generally, a lithological sequence. A natural gamma trace over a coal bed with high clay content could be interpreted as a sandstone, while kaolinitic shale with a low potassium content may produce a trace much like that of a coal seam. A clean sandstone with fresh formation water can also exhibit remarkably high electrical resistivity. The density trace of a thin coal seam can be very similar to that of a soft bentonite layer. Hole wall irregularity affects the response of both the resistivity and density logs, and caving and mud erosion are common in the often poorly consolidated strata enclosing the coal as well as in the coal

seams. A combination of log types is thus essential for lithologic interpretation.

The accuracy obtainable in defining sharp lithologic boundaries is a function of logging speed and time constant for instruments dependent on radioactive measurement, such as the natural gamma, neutron and density surveys; and on electrode spacing for electrical logs, given smooth hole wall conditions. In the example given in Figure 4, the logging speed is 12 feet per minute and the time constant for the natural gamma counter is 4 seconds, allowing a theoretical boundary definition interval of 0.8 feet. The resistivity portion of the tool, consisting of a single point, continuous reading resistivity instrument, in theory reacts instantaneously to changes in lithological character.

Without a caliper device to measure hole dimensions and roughness, as was the case for the 1976 surveys, the precision of the density and resistivity measurements is reduced because the instruments do not discriminate between the rock walls of the hole and circulation fluids occupying any spaces between the sonde and the hole wall. As the tool used in 1976 employed a spring-loaded skid to force the tool against the hole wall, the effects of hole size were assumed to be minimal.

The natural gamma-neutron borehole surveys were

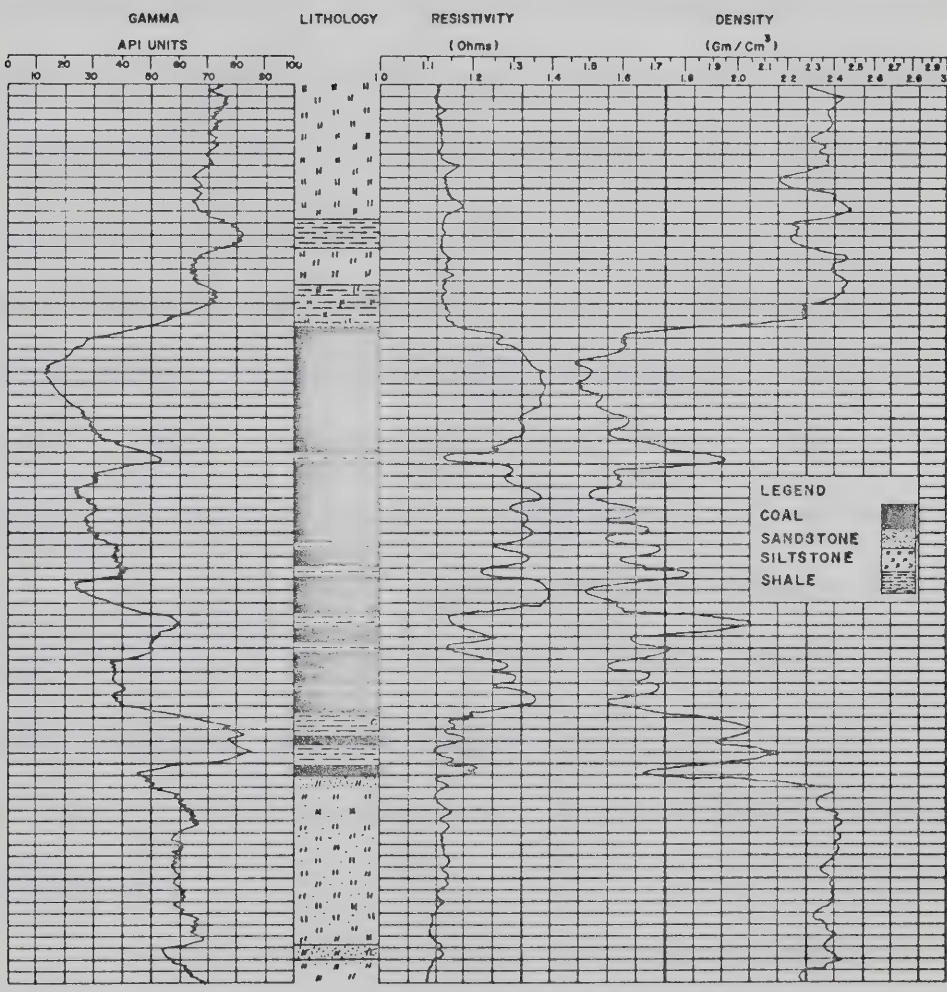


FIGURE 4 : TYPICAL MYNHEER 'A' SEAM INTERSECTION ADJACENT TO POD (BH 1702 , LINE 37+62 , STATION 620 RIGHT GEOPHYSICAL SPECIFICATIONS : LOGGING SPEED 12 f.p.m , GAMMA RAY - TIME CONSTANT 4 SEC. , SCALE - 10 API UNITS PER LOG DIVISION ; RESISTIVITY- SCALE 50 Ohms PER LOG DIVISION ; DENSITY - TYPE : FOCUSED , TIME CONSTANT 1 SEC.

normally made through the drill string where unstable hole conditions were encountered, taking advantage of the relatively small diameter of the sonde. The confidence placed in the interpretation of this combination of logs is relatively low because of the variable attenuation arising from the walls and joints of the drill string and the unknown and presumably irregular spacing between the drill string and the walls of the hole. The neutron-neutron tool in essence measures the backscatter of neutrons produced by the bombardment of the hole wall material by a neutron stream from a radioactive source in the sonde. The variation indicated by the log trace is related to the hydrogen content in the field of measurement, and thus the porosity, of the strata encountered in the hole. Coal, however, is a neutron absorber, and thus shows an anomalously low proportional neutron count on the logs, ie. an apparently anomalous high porosity.

The logs of all of the 372 geophysically surveyed boreholes drilled in the Mynheer A zone were examined, and for the most part, re-interpreted or picked to ensure consistency. During log interpretation, lithological discrimination was based primarily on the natural gamma log, qualified by the resistivity, density and neutron logs where available. In some cases, where only density or caliper-

density logs were available, the lithology was taken as that defined in the drillers' logs (eg. borehole 638, see Figure 7).

The log interpretations thus arrived at were used as a basis for the construction of 59 cross sections at 200 to 500 foot intervals along the length of the pod zone, from line -40+00 to line 160+00. On each section all pertinent surface and subsurface data were plotted, and taken into consideration in establishing the coal pod boundaries. Seven of these sections, selected as representing general pod geometry, are reproduced in Figures 5 through 11 (see Appendix B). Structure contour maps of the top and bottom of the pod (see Figure 12) and a coal pod isopach map (see Figure 14) were also constructed as aids to interpreting coal pod geometry. Because of their widely variable nature, indicated in both the subsurface and in outcrop, and the nature of this study, lithological correlation of the strata enclosing the pod was not attempted beyond the cross sections. The coal pod boundaries as plotted on the cross sections were derived from the structure contour maps, and precise correspondence of the coal pod boundary and borehole intersection projected from off the section are purely fortuitous. Borehole projections on the working sections were made normal to the plane of the section, and generally restricted to

distances of less than 50 feet from the plane of the section to remain within the limits of accuracy for the construction. In this manner, any discrepancy in boundary elevation arising from the dip of the pod boundary away from the section was minimized.

Whereas some interpretations depicted on the illustrated sections appear to be unsupported, such conclusions are based upon interpolated data from beyond the 50 foot limit of influence, and upon adjacent sections. All available surface data were plotted on the working sections; such data do not appear on the illustrations because, by chance, outcrops do not occur within the area of influence of these sections.

The structure contour maps and the isopach map of the coal pod (Figures 12 and 14) were constructed on the interpreted geological boundaries of the coal pod, and do not necessarily reflect, nor are intended to represent, the economic or mining limits of the body.

6.0 Structural Geology

6.1 Coal Pod Geometry

Based on observations gathered in the field and compilation and interpretation of subsurface data, a more or less detailed picture of the shape and structure of the Mynheer A coal pod can be discerned, in spite of the fact that much of the near-surface portion of the pod has been removed or obscured by the excavations, backfilling and waste dumps of past mining operations.

In general, the coal pod can be described as an elongate, irregular body of coal trending approximately northwest-southeast, approximately 3 3/4 miles long, 200 to 1400 feet wide and varying in thickness from the normal 15 to 30 feet of the normal Mynheer seam to a maximum of over 300 feet.

Broadly, the pod can be divided longitudinally into three sections increasing in complexity from northwest to southeast. Northwest of line 60+00, the shape of the pod is relatively simple, consisting essentially of a mildly distorted wedge, dipping shallowly toward the southwest (see Figures 5 and 6). To the northwest, the pod diminishes gradually in thickness until the normal dimensions of the Mynheer seam are reached beyond line -40+00. Southeastward, the pod increases in thickness and the main body of

coal becomes more upright or vertical. Although most of the evidence has been removed by mining, much of this portion of the pod presumably at one time cropped out at the surface. A small fold in the strata overlying the pod was observed in outcrop between lines 10+00 and 20+00, where drilling has shown a thickening of the coal. The occurrence of the unnamed coal seam indicated in Figure 6 is based on borehole data. Its orientation is supported by bedding plane measurements from outcrops north of the baseline at line 30+00.

The second section of the pod extends from about line 60+00 to approximately line 109+00. The general shape of the pod in this section is the grossly thickened wedge of the southeastern portion of the previous section, but bounded on the northeast side by a northeast-dipping fault plane (see Figures 7 and 8), observed in outcrop (see Plates I and II), and confirmed by drilling. As indicated by drilling, a short, steeply dipping to vertical splay trends southward from the northeast pod boundary fault, partially transects the pod, and disappears into a small monoclinal thickening on the southwestern edge of the pod at about line 65+00 (see Figure 12). The apex of the coal wedge in this section is overturned as it approaches the boundary fault (see Plate I). Southeast of about line 75+00, the apex of

the coal wedge is truncated by a shallow northeast-dipping fault (see Plate II, Figure 7).

In the southeasternmost section, from line 109+00 to about line 158+00, the coal pod, except for the coal face exposed at line 111+00, does not crop out. The drastic change in shape of the pod in this section (see Figures 9, 10 and 11) is extrapolated from data derived from the numerous boreholes drilled in this area. The shape of the pod in this section is broadly anticlinal, dipping shallowly to the northeast and southwest.

The northeast boundary fault, characteristic of the pod section to the northwest disappears abruptly into the coal pod at about line 109+00.

Southeast of about line 109+00, a secondary pod parallels the strike of the main pod to about line 122+00, where it diverges, plunging more nearly southward away from the main pod (see Figures 12 and 13). Based on the boreholes intersecting this secondary pod, its roof is seen to be strongly anticlinal in shape, while the floor remains shallowly monoclinal, dipping to the southwest (see Figures 9 and 10).

The main pod southeast of line 109+00 is highly complex, the roof of the pod being more strongly deformed than the floor. Southeast of about line 115+00, the apex

of the pod is increasingly overturned to the southwest, forming a tongue of coal extending southwestward from the main body of coal (see Figures 9, 10 and 11).

Southeast of line 130+00, the extent of the main pod diminishes to about line 158+00, where it terminates abruptly against the Reco Fault.

A steeply northeast-dipping reverse fault, with a throw of about 120 feet, and striking subparallel to the pod, intersects the main pod southeast of line 122+00, on the northeast side of the baseline (see Figures 10 and 12).

Within the Mynheer A pod, the coal is closely broken, with the dominant orientation of slip surfaces parallel to the enclosing walls near the pod boundaries. Toward the centre of the pod, the coal is increasingly contorted and sheared (see Plates I through VI). Of particular note in Plate I are the injection tongues of coal into the overlying sandstone along the right hand pod margin and the lineation in the coal parallel to the boundary fault which forms the left hand margin of the pod. In Plate II, the deformation of the coal can be seen on the face of the lowermost mining bench. Plate III illustrates several features of interest, ie. the general parallelism in the coal in the upper and left portions of the exposure, the contorted nature of the coal below, in the centre and right portions of

the exposure and the rotationally fractured sandstone inclusion near the right margin of the pod. Plates IV and V illustrate in more detail the degree of contortion occurring in the lower centre of the exposure. The variable but generally isoclinal folding and close shearing common to the coal in the pod interior is well illustrated in Plate VI, from the northwestern, less complex, area of the pod zone.

The closely broken and frequently contorted nature of the coal within the pod, together with the occurrence of injection tongues into the surrounding strata as seen in Plate I and the roof rock inclusion as seen in Plate III indicate a predominantly pseudoplastic deformation history of coal movement. The greater degree of deformation of strata overlying the pod than that underlying it indicates that a greater amount of shortening has occurred in the superposed sheet than has affected the floor of the pod. The coal has apparently served as a zone of compensation, flowing into areas of lower pressure created by this differential movement.

6.2 Structure of Strata Enclosing the Coal Pod

In order to gain an overall picture of the structure of the Mynheer A zone, a computer analysis of bedding orientations was undertaken. Bedding orientations from outcrops in the Mynheer A zone were analysed by dividing the zone into 11 areas and calculating the best-fit fold-axis in each using a method described in Charlesworth et al. (1976). Although considerable variation in fold-axis orientation was found, there was a tendency for the areas to form two groups. Northwest of line 60+00, the best-fit fold axis has a trend of 128° and a plunge of 1°, with comparatively little scatter of the bedding poles (see Figure 15). Southeast of this line, the best-fit fold axis has a trend of 137° and a plunge of 9°, with four times as much scatter (see Figure 16).

A dominant anticlinal structure characterizes the Mynheer A zone, with strata northeast of the baseline dipping primarily to the northeast and those to the southwest of the baseline, southwestward. Northeast of the baseline, and within the pod zone, smaller fold and fault structures increase the complexity of the structural pattern. Three major faults dominate the overall structural pattern. These consist of the following (see Figures 2 and 13):

a) a steeply northeast-dipping, irregularly north-

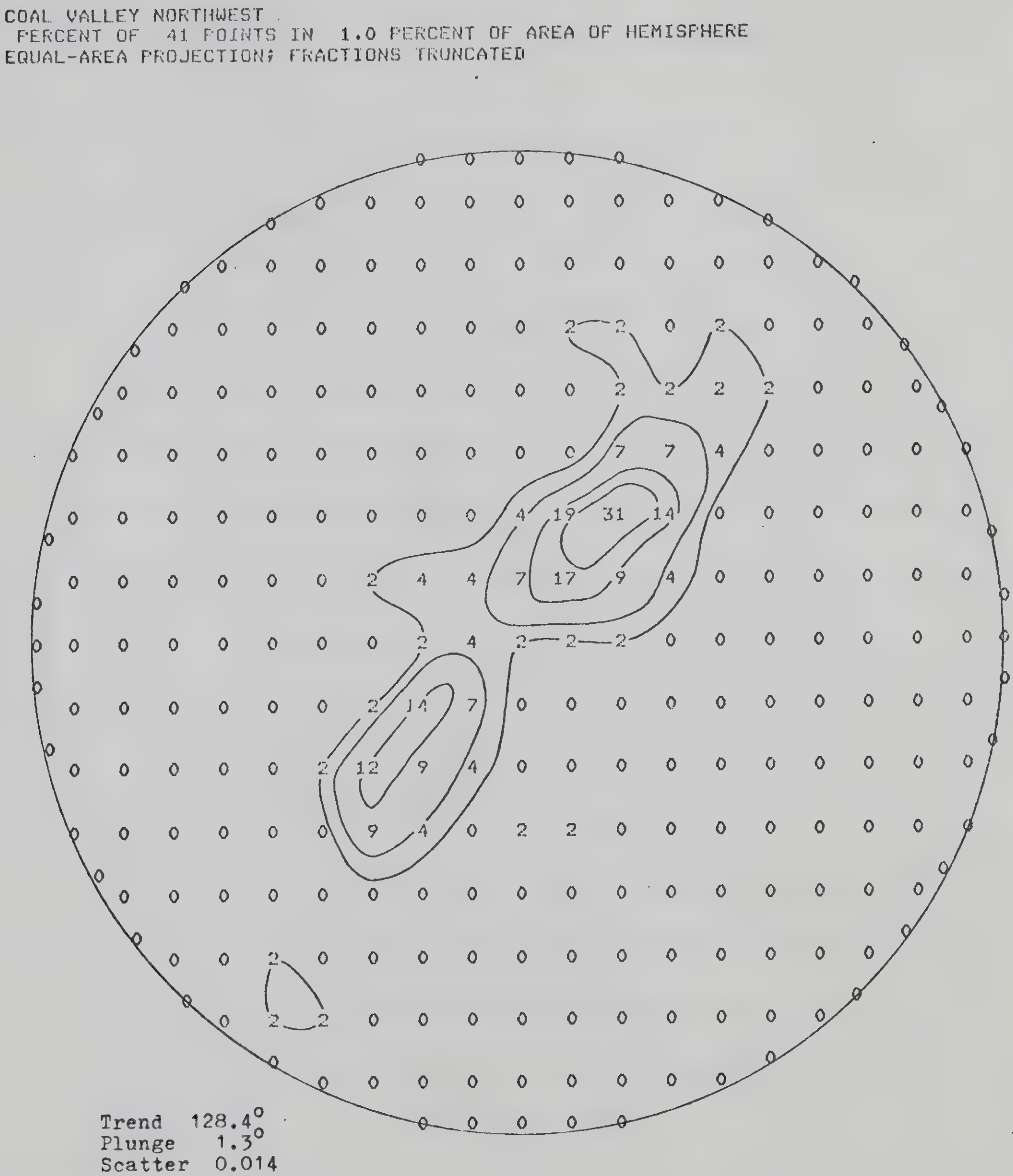
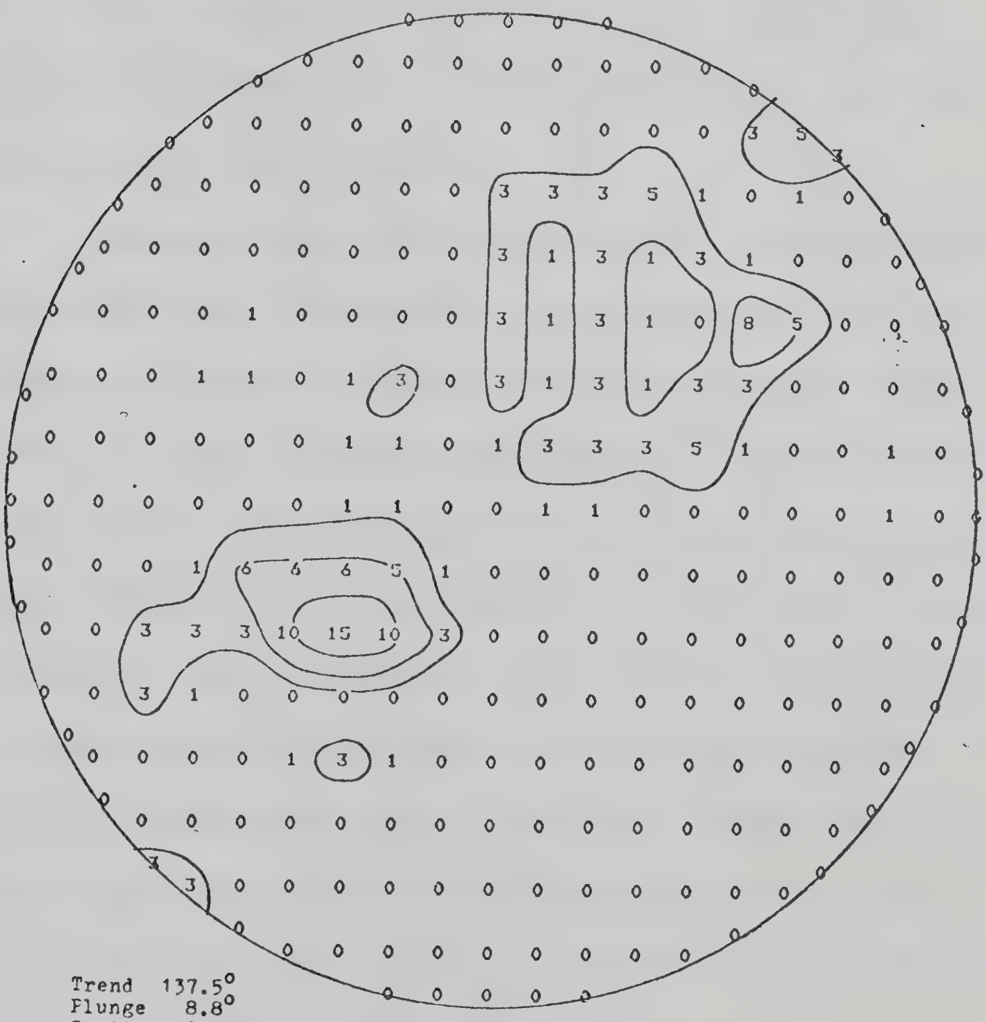


Figure 15: Computer generated pi-diagram of outcrop bedding orientations northwest of line 60+00.

COAL VALLEY SOUTHEAST
PERCENT OF 58 POINTS IN 1.0 PERCENT OF AREA OF HEMISPHERE
EQUAL-AREA PROJECTION; FRACTIONS TRUNCATED



Trend 137.5°
Plunge 8.8°
Scatter 0.055

Figure 16: Computer generated pi-diagram of outcrop bedding orientations southeast of line 60+00.

west-trending reverse fault intersecting and truncating the coal pod between lines 58+00 and 109+00;

b) a steeply dipping to vertical north-trending fault intersecting and terminating the coal pod at about line 158+00; and

c) a shallow, northeast-dipping thrust fault which has projected a sheet of strata partially over the southern half of the pod zone.

Between lines 58+00 and 109+00, a northeast-dipping reverse fault intersects and truncates the coal pod (see Figures 7 and 8). Although the fault is quite irregular in plan (see Figure 13) and varies in dip from 35° to 80°, the general trend of this fault is subparallel to the baseline with average dips from 60° to 70° to the northeast. The strata of the northeastern fault block are assumed to be stratigraphically lower than the southwestern block, as there is no correlation of borehole data across the fault, and the unique succession of thin volcanoclastic strata seen in outcrop on line 75+00 are not observed to the southwest where strata overlying the Mynheer seam are exposed. Northwest of line 90+00, the strata of the northeast block appear to dip monoclinally northeasterly at about 30°, whereas to the southeast the strata have been folded, with southerly dips of 25° to 60° predominating. A thin coal seam,

which is not correlatable in subsurface across the fault, occurs in outcrop and is intersected by boreholes in this block between lines 96+00 and 106+00. This seam appears to be one of the thin, impersistent seams common throughout the Saunders Formation. To the north of line 58+00, the fault apparently swings northward, beneath the edge of the northeastern thrust sheet. The radical change in strike is marked by a short south-trending splay fault intersecting the coal pod. At line 109+00, the fault abruptly disappears into the coal pod.

Because the fault occurs where the pod reaches an apparent thickness of over 300 feet and the strata on each side of the fault are not correlatable, it is assumed that vertical fault movement is in excess of 300 feet. The total amount of fault movement is not known at this time.

The southeastern limit of the Mynheer A coal pod occurs at a prominent, approximately north-trending fault, herein called the Reco Fault, which intersects the baseline at approximately line 158+00. A surface expression of transcurrent movement along this fault is exhibited in the offset of the Lovett River syncline and Beaverdam Fault (see Figure 2). Although the Lovett River is strongly offset in following the course of a portion of this fault, there is no topographic expression to suggest that the fault is continuous

into the thrust sheet to the north (see Figure 13). That the fault is continuous beneath the sheet is revealed by the abrupt termination of the Mynheer A coal pod and the distortion of the Mynheer B coal seam at this point. A north-trending lineament, without apparent southward continuation, does occur in the thrust sheet at approximately line 109+00, some 4900 feet northwest of line 158+00. This lineament is considered to have been caused by the continuation of the Reco Fault in the thrust sheet, and is referred to as the Reco Fault Extension (see Figure 13).

Recent drilling in the fault area south of Reco suggests that the fracture may be complex, particularly where it approaches the Beaverdam Fault.

Movement along the Reco Fault was apparently both transcurrent and normal. Sinistral transcurrent dislocation is apparent in the offset of the Lovett River syncline. Normal dip-slip movement is indicated by the juxtaposition of the Mynheer A pod and the Mynheer B coal seam. The latter exhibits characteristics similar to the Mynheer A seam downdip of the pod - ie. a seam thickness of 17 to 30 feet, and relatively gentle dips of 8 to 20 degrees southwestward. A vertical component of fault movement of the southeastern block is necessary to elevate the Mynheer B seam to its present position.

The thrust sheet partially projected over the southeastern half of the coal pod (see Figures 2 and 13) is one of the major structural elements of the Mynheer A zone. The leading edge of the thrust sheet, observed in outcrop between lines 83+00 and 86+00 in the walls of the Luscar-Sterco Limited 1974 test pit, appears to dip northeasterly at approximately 10°. This edge was traced southeastward and northward using photogeologic techniques to a junction with the Lovett Fault.

The northern portion of this thrust sheet northeast of the pod zone has been deformed into at least one large scale anticline-syncline pair (see Figure 2) and numerous small scale folds and faults occur. Surficial erosion of these structural features has produced the relatively rugged topography of this area as contrasted with that of the structurally simpler surrounding areas. Of particular note is a small anticline-syncline pair along the edge of the thrust sheet southeast of line 116+00, in which the anticline occurs above the centre of the main coal pod and the syncline adjacent to the southwest is partially underlain by an extention or tongue projecting from the main body of coal (see Figures 10 and 11).

The thrust sheet forms the roof of the main coal pod southeast of line 109+00, the fault plane occurring at

the junction of the coal and the roof strata. Between line 78+00 and 83+00, where the strata have not been disturbed by mining, the thrust sheet edge truncates the apex of the wedge-shaped coal pod (see Figure 7). Comparison of geophysical survey traces from boreholes penetrating the thrust sheet show no correlation between the strata of the thrust sheet and those underlying the area to the southwest of the thrust sheet.

The throw of this thrust fault is estimated to be about 5500 feet, based on the offset between the Reco Fault and the Reco Fault Extension, and assuming that thrust movement took place normal to the regional strike.

7.0 Summary and Conclusions

Little published data are available on the geology of the Outer Foothills of the Rocky Mountains in the Coal branch area of Alberta. The Mynheer A zone, centred on an extensive pod formed in the lowermost or Mynheer seam of the Coalspur coal measures, has not been subjected to a detailed structural investigation. The purpose of this thesis is to present an interpretation based on such a study of the geometry of the coal pod and its structural setting.

The Coalspur coal measures occur in the upper part of a thick accumulation of continental clastic sediments overlying the marine Cretaceous Wapiabi Formation. Confusion exists in the published stratigraphies of these sediments primarily because of the lack of suitable data.

Based on the large amount of data generated by preproduction exploration and development of the Mynheer A zone by Luscar-Sterco Limited, particularly on a large number of geophysically logged boreholes and a field mapping program by the author, a series of closely spaced cross sections, structure contour diagrams of the top and bottom of the coal pod, and a coal pod isopach map were constructed; and a surface geological map compiled. From these constructions, an interpretation of the geometry of the coal pod and its structural setting was derived.

Certain conclusions and observations may be made as a result of this study:

1) Analysis of bedding orientations from the area show two general structural regimes exist, with slightly differing, but southeasterly-trending shallow plunges.

2) The Mynheer A coal pod is an elongated body of irregular shape roughly 3 3/4 miles long by 200 to 1400 feet wide, and where undisturbed by mining, in some places over 300 feet thick.

3) Three shape elements can be distinguished along the length of the coal pod: a mildly distorted stratigraphically bound wedge in the northwestern portion; becoming more upright in the central third of the body, where it is truncated on the northeast side by a steeply northeast-dipping reverse fault and at the apex by a shallowly northeast-dipping thrust fault; and a strongly distorted anticlinal form in the southeastern third.

4) The pod bifurcates toward its southeast end, forming a smaller anticlinal pod southwest of the main pod.

5) In the southeastern third, a shallow northeast-dipping thrust intersects the top of the main coal pod, producing an extention or tongue of coal projecting to the southwest and folded with the leading edge of the thrust sheet.

6) The strongly southwest-dipping strata overlying the southwestern side of the Mynheer seam dip more moderately away from the pod zone into the Lovett River syncline.

7) At its southeastern end, the coal pod terminates abruptly against the steeply dipping to vertical north-trending Reco Fault.

8) In the southeastern portion of the pod zone, a steeply northeast-dipping reverse fault with a throw of approximately 120 feet and trending sub-parallel to the main pod, intersects the pod northeast of the baseline.

9) The shallow thrust sheet which dominates the structure of the southeastern end of the pod underlies most of the area between the pod zone and the Lovett Fault to the northeast. The folding and common small-scale normal and thrust faulting in the thrust sheet to the northeast of the pod zone is the basis for the rugged topography of the area. The throw of the major thrust fault is estimated to be in the order of 5500 feet.

10) Movement along the Reco Fault is seen to be transverse, comprised of sinistral lateral and vertical components, producing the present juxtaposition of the Mynheer B seam and the Mynheer A pod.

11) Small-scale folding and faulting occur along

the length of the coal pod, increasing the complexity of its geometry.

12) The coal in the pod has acted as a zone of compensation and slippage between the substantially shortened overlying strata and the relatively undisturbed underlying strata. Deformation of the coal was primarily pseudoplastic in mode.

8.0 Selected References

Alberta Department of Business Development and Tourism. 1975. Industry and Resources 1975, Edmonton.

Allan, J.A. and Rutherford, R.L. 1923. Saunders Creek and Nordegg Coal Basins, Alberta, Canada. Sci. and Ind. Research Council of Alberta, Rep. 6, 66p.

-------------------------------- 1924. Geology along the Blackstone, Brazeau and Pembina Rivers in the Foothills Belt, Alberta. Sci. and Ind. Research Council of Alberta, Rep. 9, 53p.

Bell, W.A. 1949. Uppermost Cretaceous and Paleocene floras of western Alberta. Geol. Surv. Can., Bull. 13, 231 p.

Carroll, W.F. 1947 (chairman). Report of the Royal Commission on Coal 1946. Morrison, A.J. and MacLaurin, C.C., members, Parliament, House of Commons, Ottawa, pp. 32-42, 105-106, 226-243, 322, 335, 444, 451, 468.

Charlesworth, H.A.K., Langenberg, C.W., and Ramsden, J. 1976. Determining axes, axial planes and sections of macroscopic folds using computer-based methods, Can. J. Earth Sci. 13, pp. 54-65.

Cote, J.L. 1921 (witness). Official report of evidence taken during session of 1921 respecting future fuel supply of Canada by a special committee of the House of Commons, King's Printer, Ottawa, pp. 79-80.

Dowling, D.B. 1908. Explorations in the Rocky Mountains. Geol. Surv. Can., Summ. Rep. 1907, pp. 32-34.

------------ 1909. The coal fields of Manitoba, Saskatchewan, Alberta and eastern British Columbia. Geol. Surv. Can., Ottawa, 111 p.

------------ 1910. Coal fields south of the Grand Trunk Pacific Railway, in the foothills of the Rocky Mountains, Alberta. Geol. Surv. Can., Summ. Rep. 1909, pp. 139-150.

Dowling, D.B. 1913. Coalfields of Manitoba, Saskatchewan, Alberta and British Columbia. in The Coal Resources of the World, 12th Int. Geol. Cong. 1913 (W. McInnes, D.B. Dowling, W.W. Leach, eds.), Morang and Co. Ltd., Toronto, pp. 474, 478.

------------- 1923. Investigation of artesian water, coal, petroleum and natural gas in Alberta. Geol. Surv. Can., Summ. Rep. 1922B, pp. 101-132.

Draper, H.L. 1930. The Alberta coal problem. McGill U. Econ. Stud. 15, National problems of Canada, McGill U., Montreal, 65 p.

Eliuk, L.S. 1969. Correlation of the Entrance Conglomerate, Alberta by palynology. unpubl. M.Sc. thesis, Dept. of Geol., U. of Alberta, Edmonton.

Hacquebard, P.A. and Birmingham, T.F. 1973. Petrography of the Val D'Or and Mynheer seams, Coalspur coal area, Alberta. Geol. Surv. Can., Tech. Rep. 83-F/2-1, 21 p.

Hake, B.F., Willis, R., and Addison, C.C. 1942. Folded thrust faults in the foothills of Alberta. Geol. Soc. Am. Bull. 53, No. 2, pp. 291-334.

Irish, E.J.W. 1965. Geology of the Rocky Mountain foothills, Alberta (between latitudes 53° 15' and 54° 15'). Geol. Surv. Can., Mem. 334.

Latour, B.A. 1970. Geology and enconomic minerals of western Canada; Fuels - Coal. in Geology and Economic Minerals of Canada (R.J.W. Douglas, ed.) Geol. Surv. Can., Econ Rep. 1, p. 524.

Link, T.A. 1954. Interpretations of foothills structures, Alberta, Canada. in Western Canada Sedimentary Basin, Alberta Soc. Pet. Geol. and Saskatchewan Soc. Pet. Geol. symposium (L.M. Clark, ed.). Am. Assoc. Pet. Geol., Tulsa, pp. 355-381.

Luscar-Sterco Limited. 1975. Coal Valley Project submission report to the Energy Resources Conservation Board of Alberta., Edmonton, 235p.

Mathews, W.H. and Kupsh, W.O. 1964. Tertiary. in Ceolo-

gical History of Western Canada, Ch. 13. Alberta Soc. Pet. Geol., Calgary, p. 190.

Nordegg, M. 1930. The fuel problem of Canada. Macmillan, Toronto, 155 p.

Reeves, D.R. 1970. Insitu analysis of coal by borehole logging technique. preprint 72nd meeting Can. Inst. Min. and Met., Toronto, 38p.

Ross, T. 1974. Oh! The Coal Branch - a chronicle of the Alberta Coal Branch. Friesen & Sons Ltd., Calgary, 340 p.

Rutherford, R.L. 1925. Geology of the foothills belt between McLeod and Athabaska Rivers, Alberta. Sci. and Ind. Research Council of Alberta, Rep. 11, 82 p.

Stansfield, E., Hollies, R.T., and Campbell, W.B. 1925. Analyses of Alberta Coal. Sci. and Ind. Research Council of Alberta, Rep. 14, Edmonton, 63p.

Scott, J.C. 1954. Folded faults in Rocky Mountain foothills of Alberta, Canada. in Western Canada Sedimentary Basin. Alberta Soc. Pet. Geol. and Saskatchewan Soc. Pet. Geol. symposium (L.M. Clark, ed.), Am. Assoc. Pet. Geol., Tulsa, pp. 309-340.

Tozer, E.T. 1956. Uppermost Cretaceous and Paleocene non-marine molluscan faunas of western Alberta. Geol. Surv. Can., Mem. 280, 125p.

Williams, G.D. 1970a. Geology of the Coalspur-Sterco-Pembina Forks area (Alberta Coal Branch). private company report to Luscar Ltd., Edmonton.

-------------- 1970b. Coal geology of the Saunders (Brazeau) Formation between McLeod and Blackstone Rivers, Alberta Foothills. private company report to Luscar Ltd., Edmonton.

--------------, and Burk, C.F. 1964. Upper Cretaceous. in Geological History of Western Canada, Ch. 12 (R.G. McCrossan and R.P. Glaister, eds.), Alberta Soc. Pet. Geol., Calgary, p. 182.

9.0 Appendix A: Plates

Plate I: Mynheer A coal pod exposure on southeast wall of mine pit at approximately line 74+00. Scale at the coal face is approximately 1"= 50'.

MINE BENCH
THRUST
135°
10°
INTERBEDDED SILTSTONE, SHALE, BENTONITE & TUFF
130°
45°
COAL BENCH
COAL
165°
MINE
25°
125°
85°
133°
80°
110°
80°
SANDSTONE
SILTSTONE
SANDSTONE
GOAL
POD
SLUMP

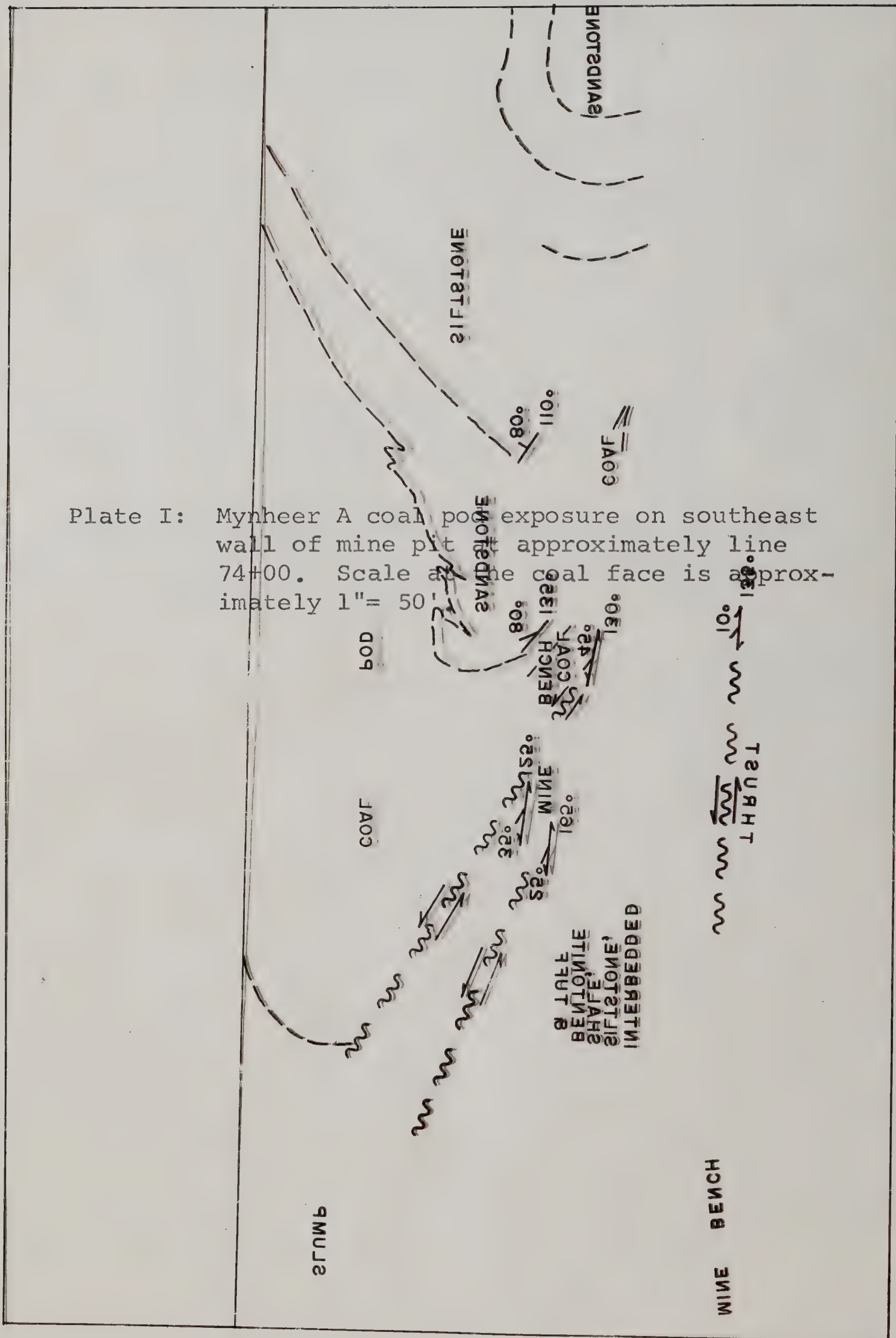


Plate I: Mynheer A coal pod exposure on southeast wall of mine pit at approximately line 74+00. Scale at the coal face is approximately 1"= 50'.

56

Plate II: Mynheer A coal pod exposure at northwest end of the Luscar-Sterco Limited 1974 test pit at approximately line 84+00. The height of the nearest coal face is about 8 feet.

SPOIL
155°
68°
SILTSTONE
SANDSTONE
160°
80°
110°
21°
MINE BENCH
MINE BENCH
MINE BENCH
COAL POD
MINE BENCH
150°
80°
CONGLOMERATE
SANDSTONE
CONGLOMERATE
SANDSTONE
SANDSTONE
INTERBEDDED
SILTSTONE
SHALE
BENTONITE
& TUFF
ROAD
MINE BENCH

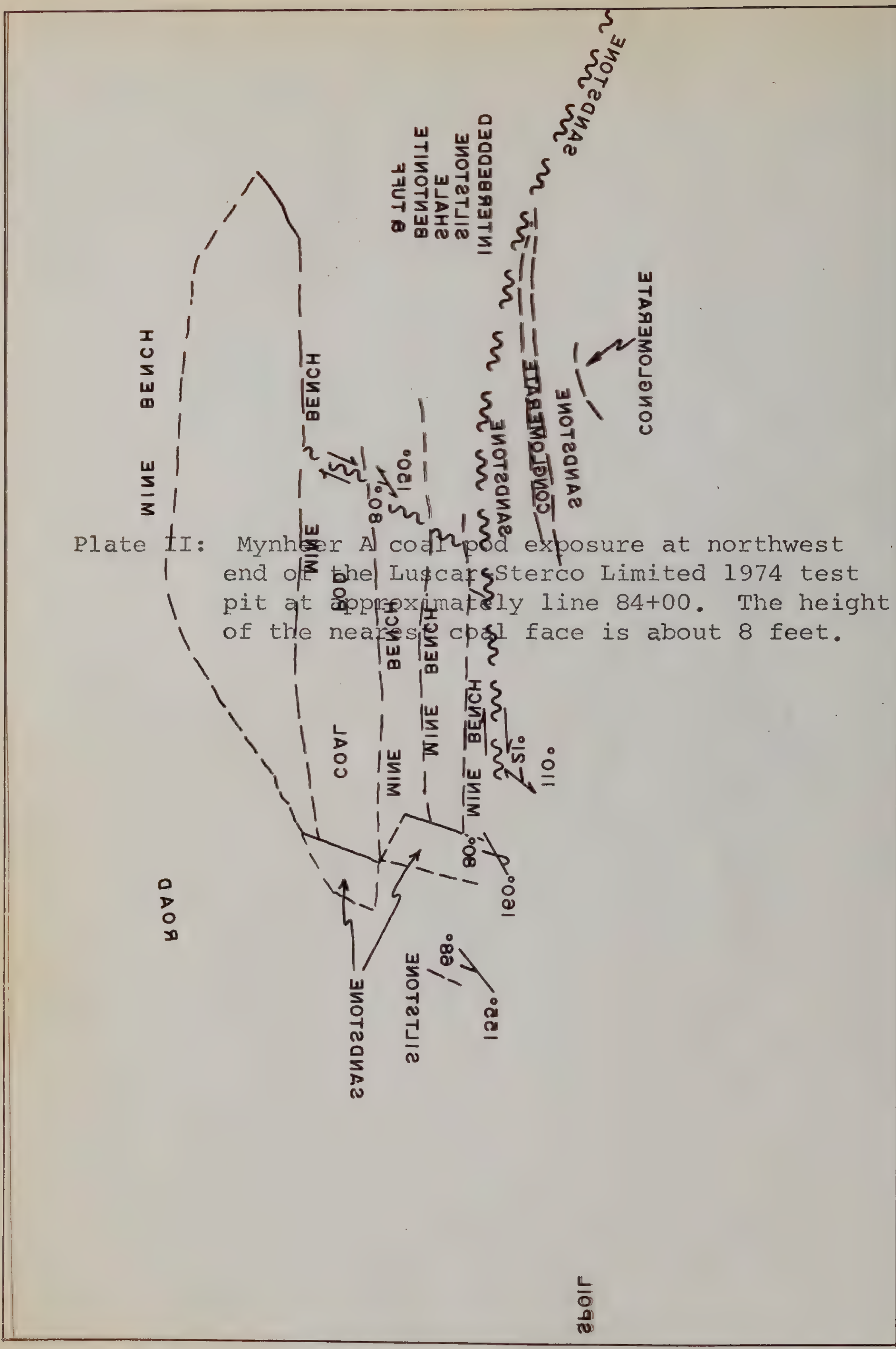


Plate II: Mynheer A coal pod exposure at northwest end of the Luscar Sterco Limited 1974 test pit at approximately line 84+00. The height of the nearest coal face is about 8 feet.

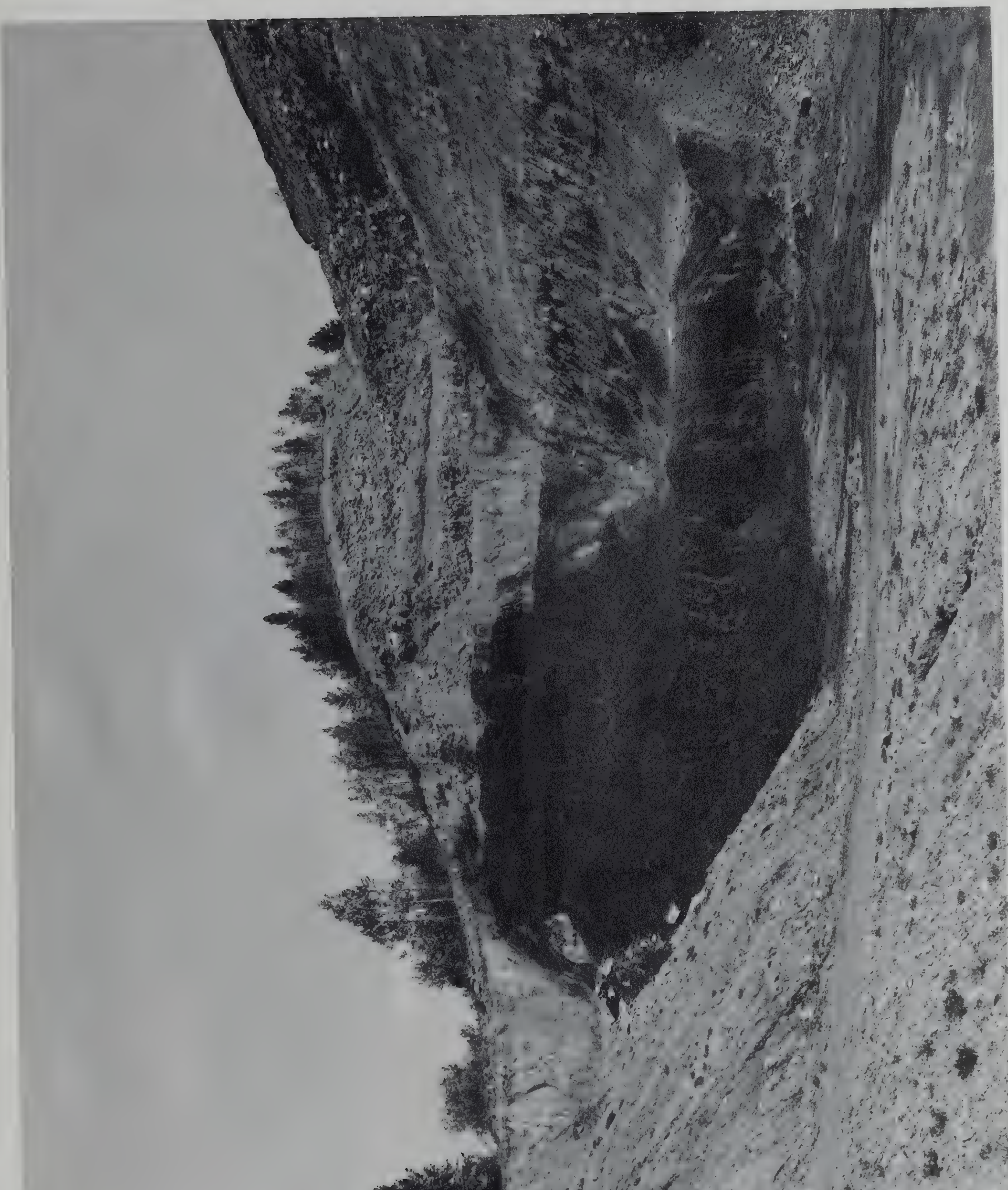


Plate III: Mynheer A coal pod exposure on southeast wall of mine pit at approximately line 111+00. At its centre, the coal exposure is about 23 feet high.


SANDSTONE
TALUS
SLUMP
SPOIL
MINE
BENCH
COAL
POD
PLATE
IV
XENOLITH
(SANDSTONE)
85°
135°
SAND-
STONE
SILT-
STONE
110°
125°
120°
SLUMP
FILL

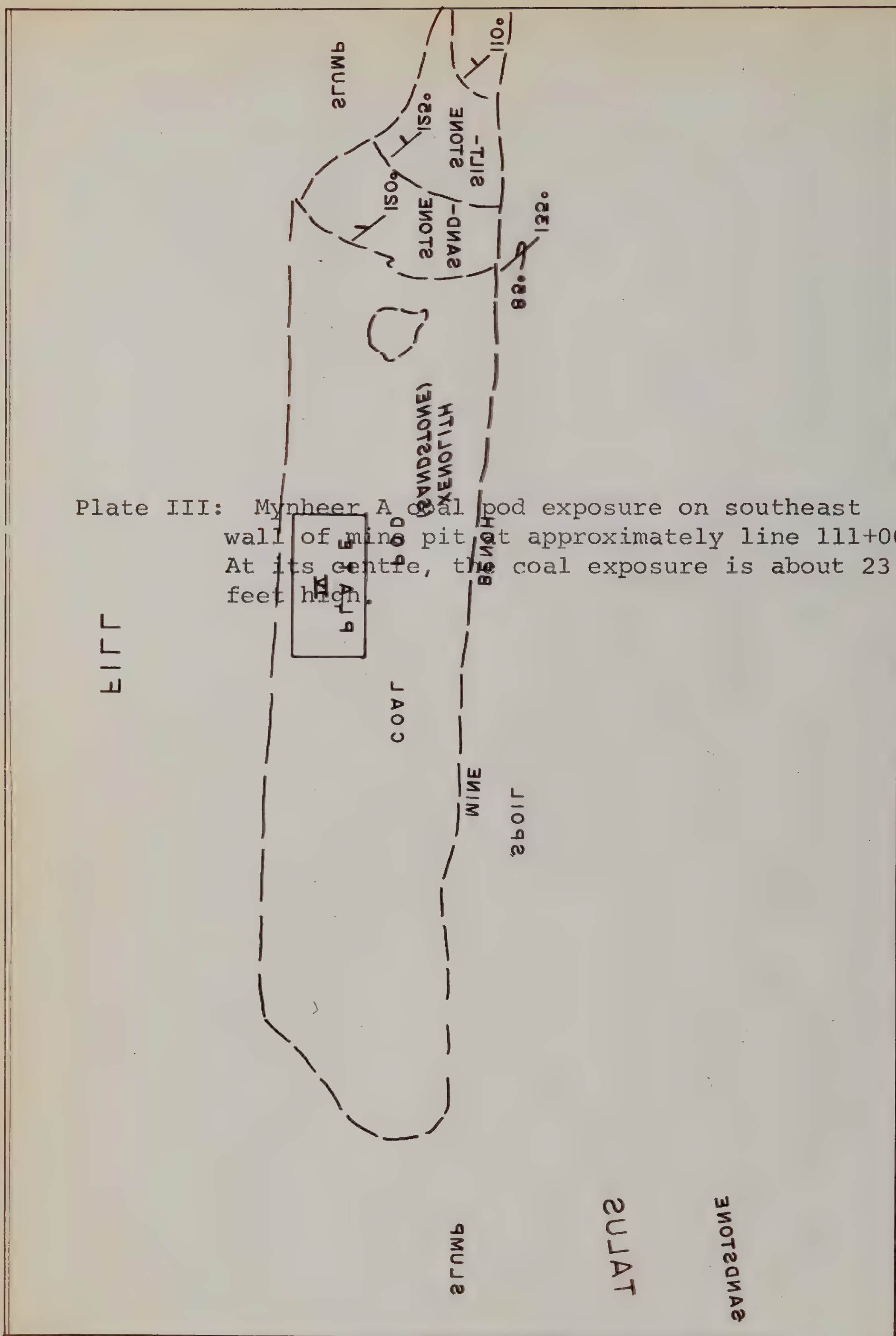
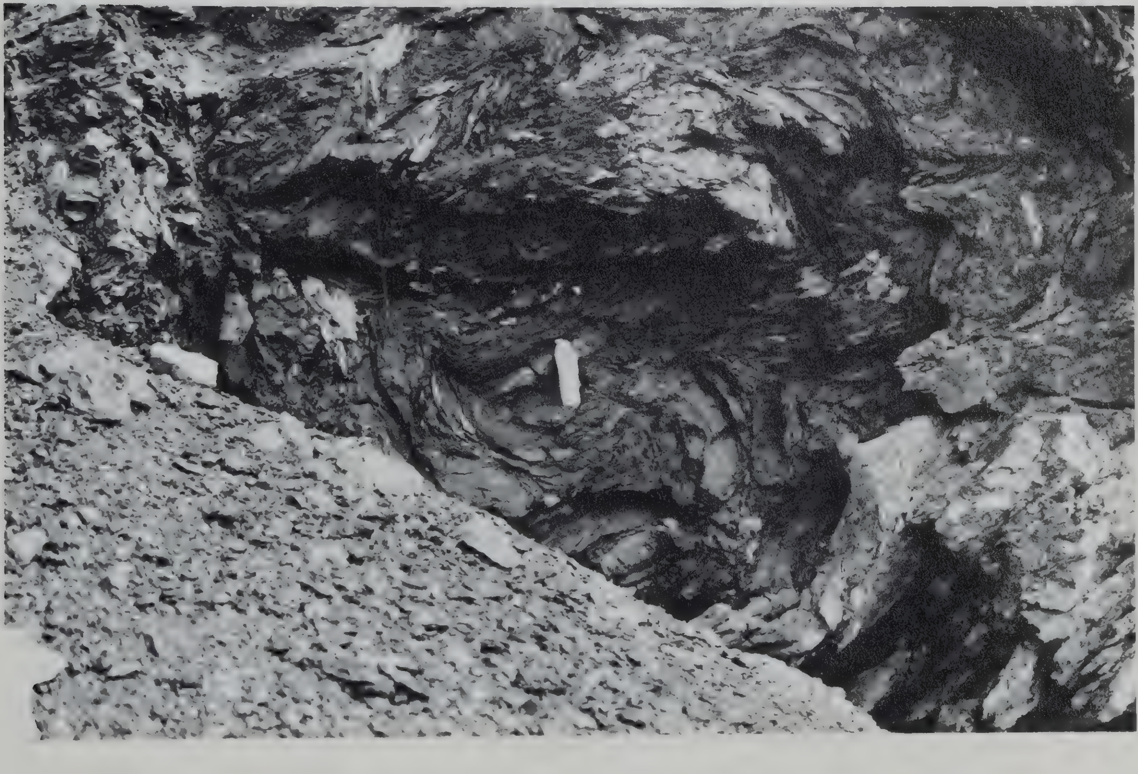
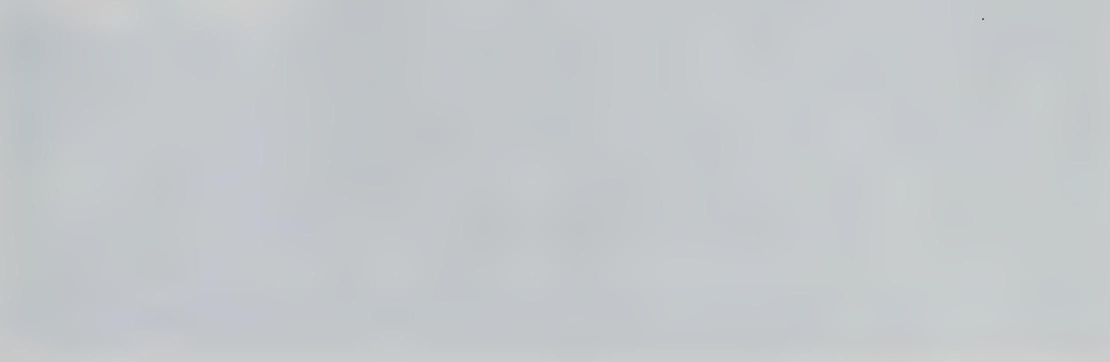


Plate III: Mynheer A coal pod exposure on southeast wall of mine pit at approximately line 111+00. At its centre, the coal exposure is about 23 feet high.

Plate IV: Closeup view of central portion of exposure shown in Plate III, illustrating degree of coal deformation. The scale is about 1"= 3½'.

Plate V: Closeup view of shadowed area in lower left quadrant of Plate IV, showing detail of small-scale structure in the coal. The pocket knife is approximately 3½" long.





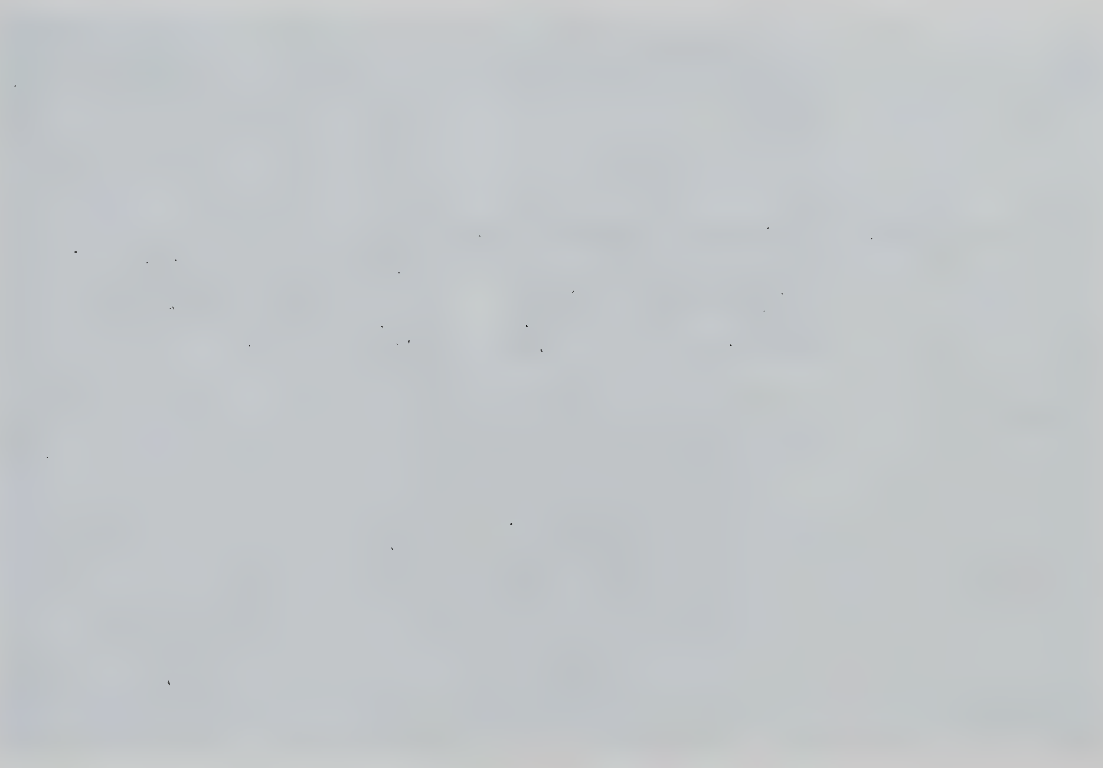
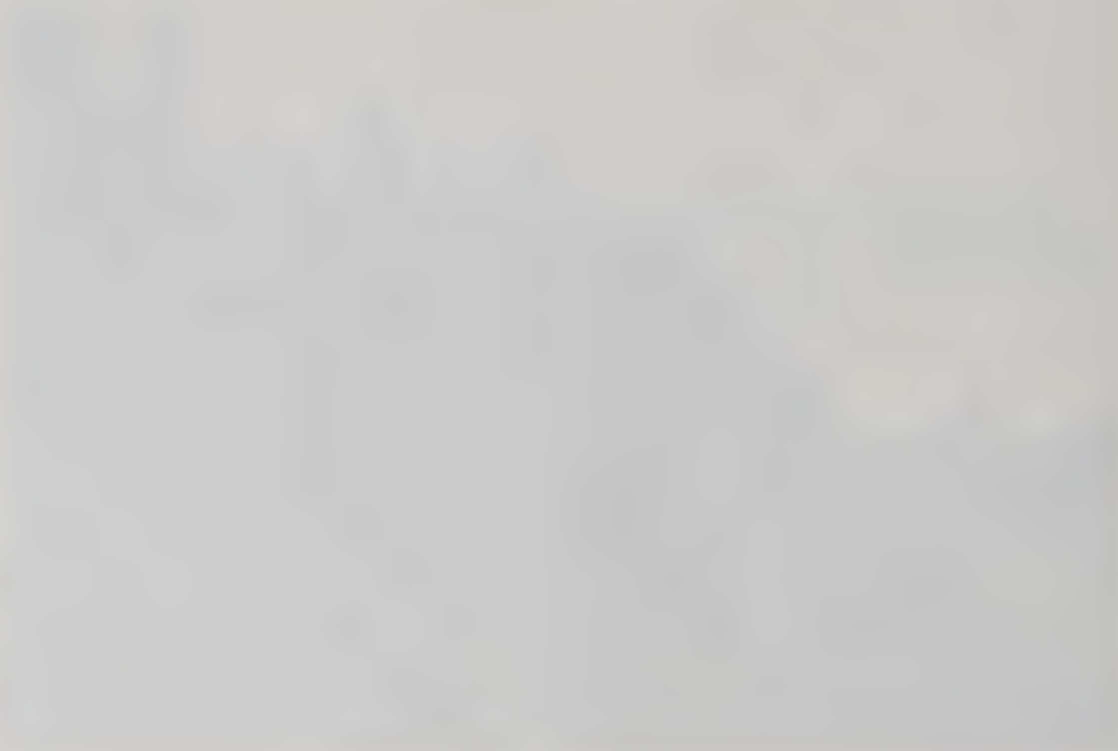
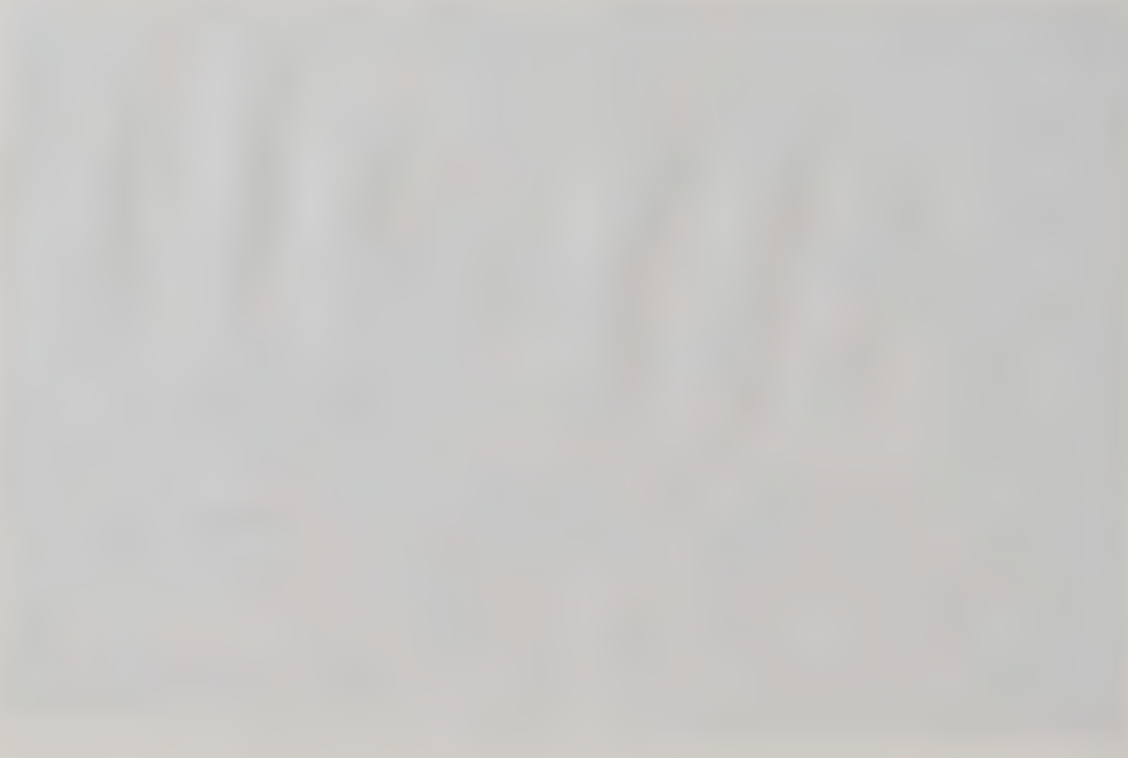


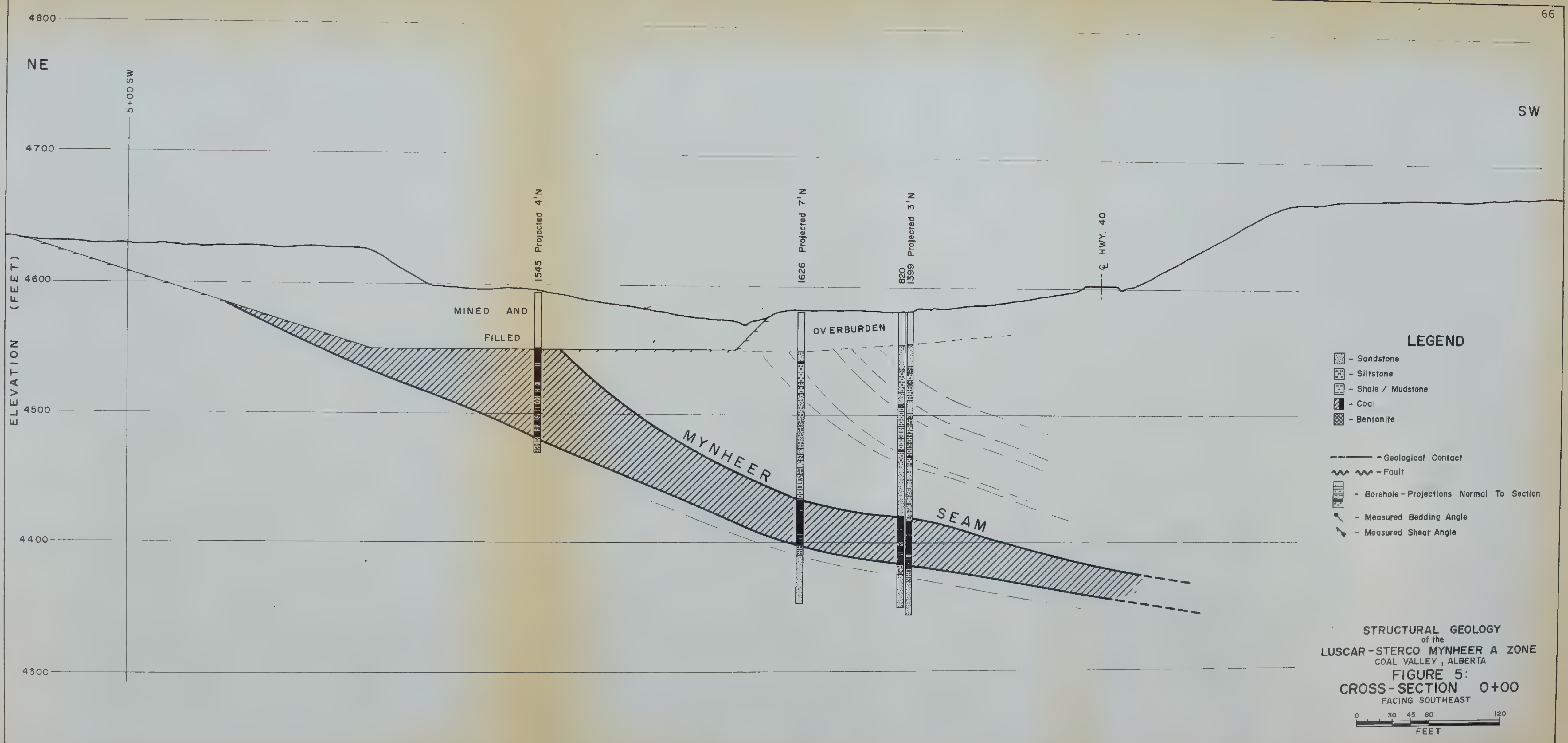
Plate VI: Mynheer A coal pod exposure on the northeast side of mine pit wall at approximately line -20+00, looking northwest. The pocket knife is approximately 3½" long.

Plate VII: Typical conglomerate lense - located at the northwest end of the Luscar-Sterco Limited test pit above the coal pod. The lense cap is 2 1/8" in diameter.



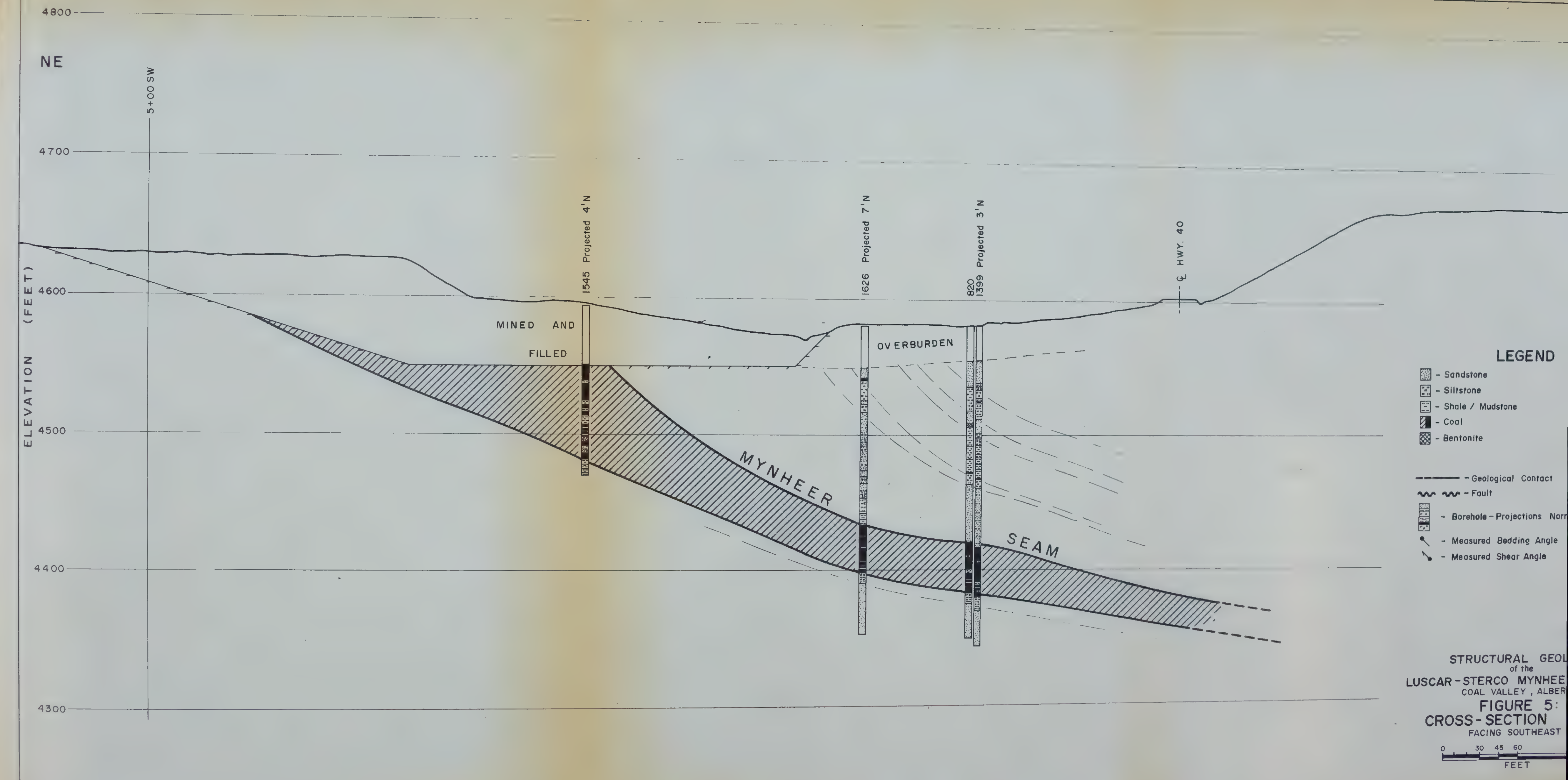


10.0 Appendix B: Figures 5 - 11



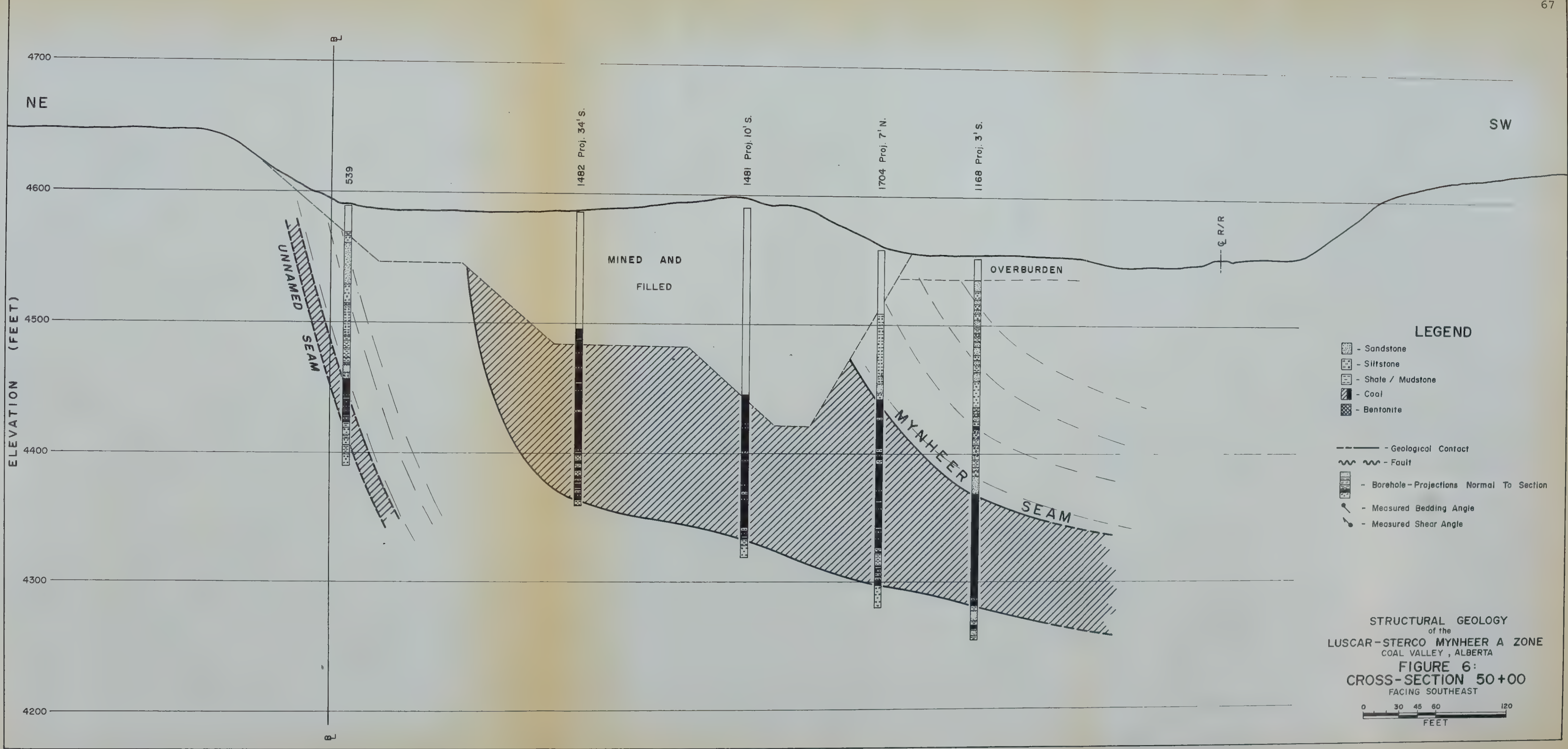
STRUCTURAL GEOLOGY
of the
LUSCAR-STERCO MYNHEER A ZONE
COAL VALLEY, ALBERTA

FIGURE 5:
CROSS-SECTION 0+00
FACING SOUTHEAST



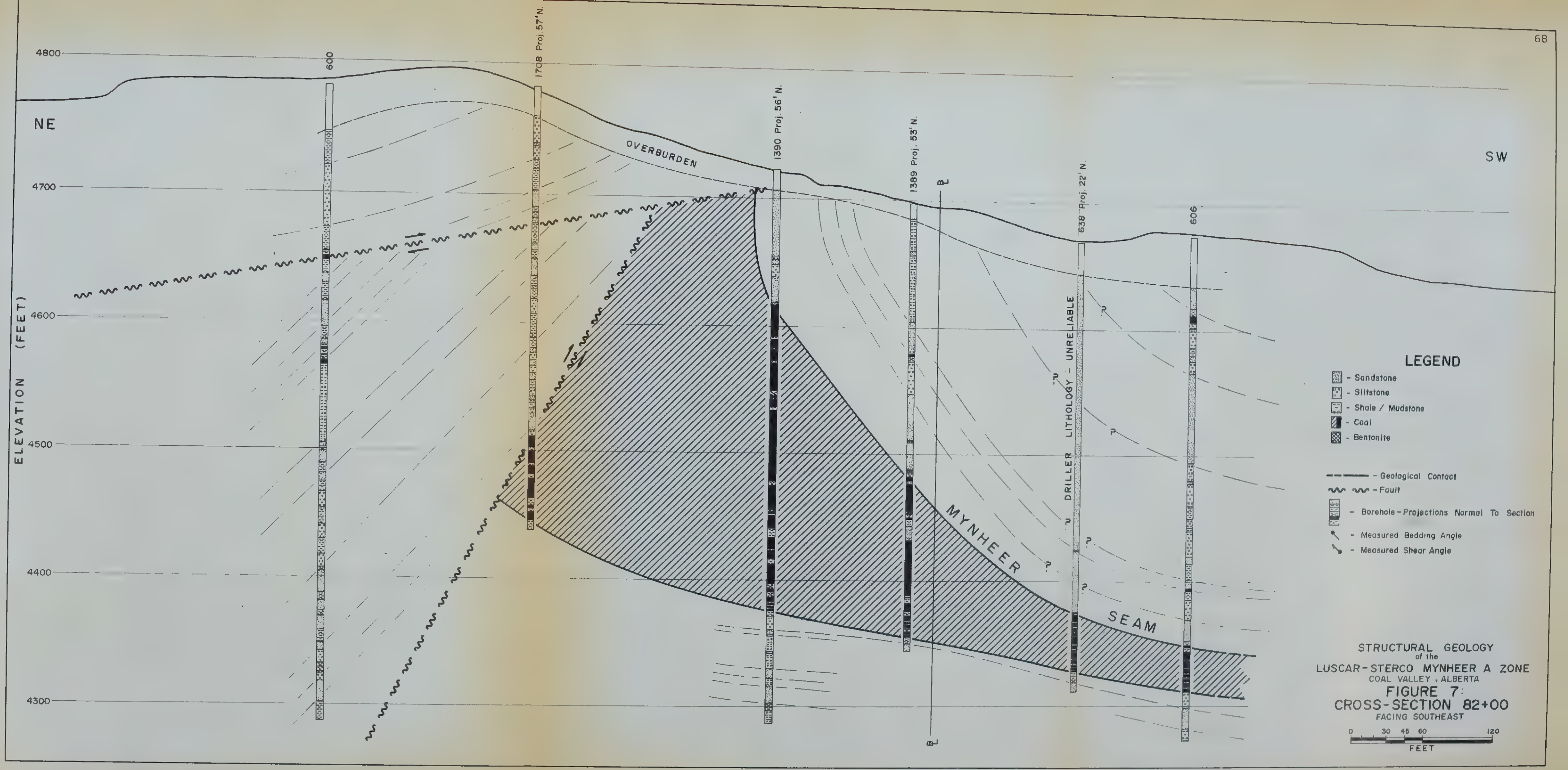
STRUCTURAL GEOL
of the
LUSCAR-STERCO MYNHEE
COAL VALLEY, ALBER

FIGURE 5:
CROSS-SECTION
FACING SOUTHEAST

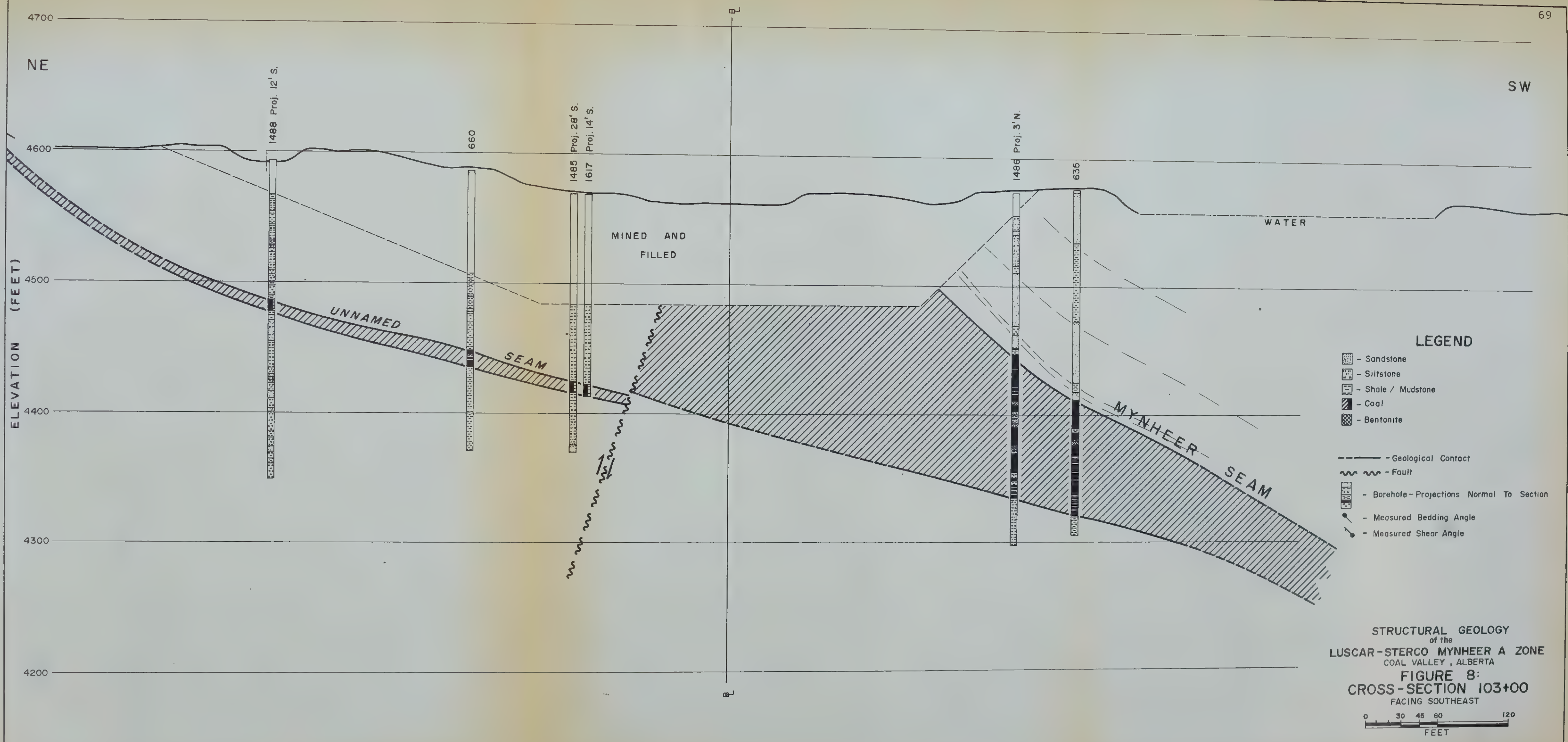


STRUCTURAL GEOLOGY of the LUSCAR-STERCO MYNHEER A ZONE
COAL VALLEY, ALBERTA

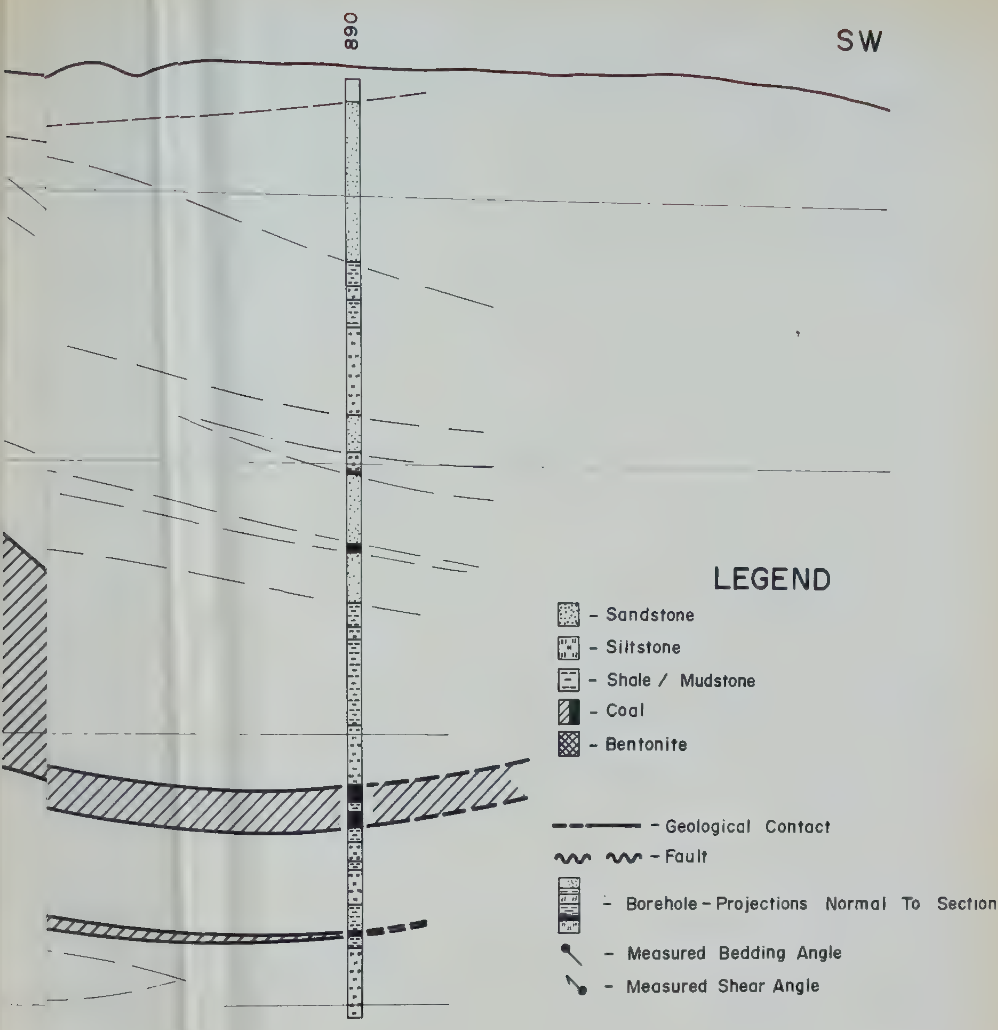
FIGURE 6:
CROSS-SECTION 50+00
FACING SOUTHEAST



STRUCTURAL GEOLOGY
of the
LUSCAR-STERCO MYNHEER A ZONE
COAL VALLEY, ALBERTA
FIGURE 7:
CROSS-SECTION 82+00
FACING SOUTHEAST

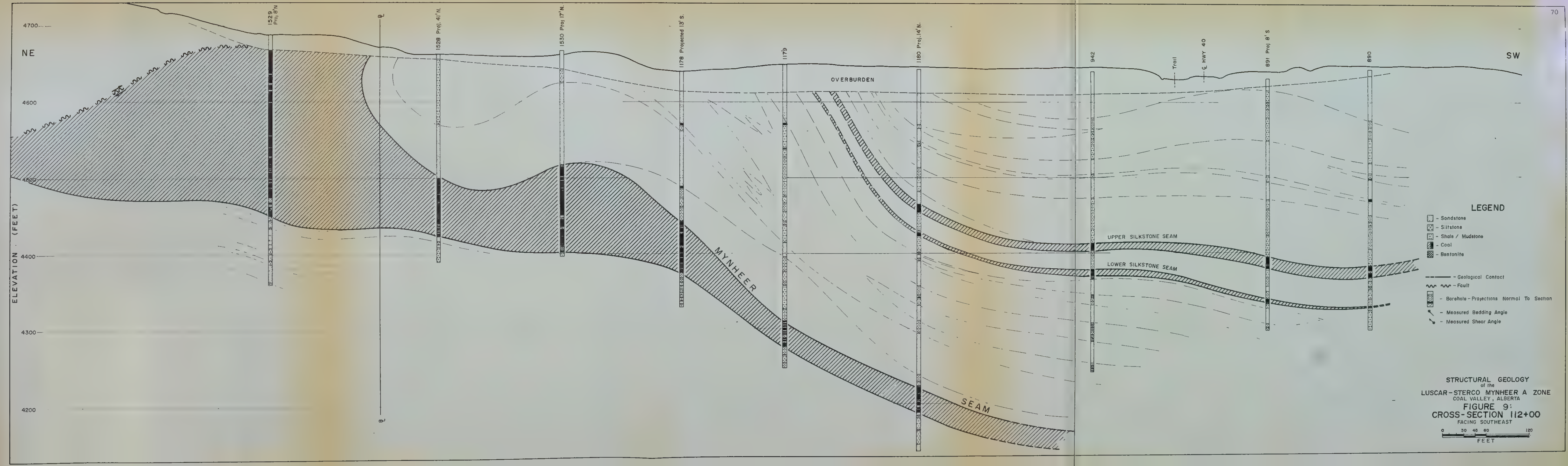


STRUCTURAL GEOLOGY
of the
LUSCAR-STERCO MYNHEER A ZONE
COAL VALLEY, ALBERTA
FIGURE 8:
CROSS-SECTION 103+00
FACING SOUTHEAST

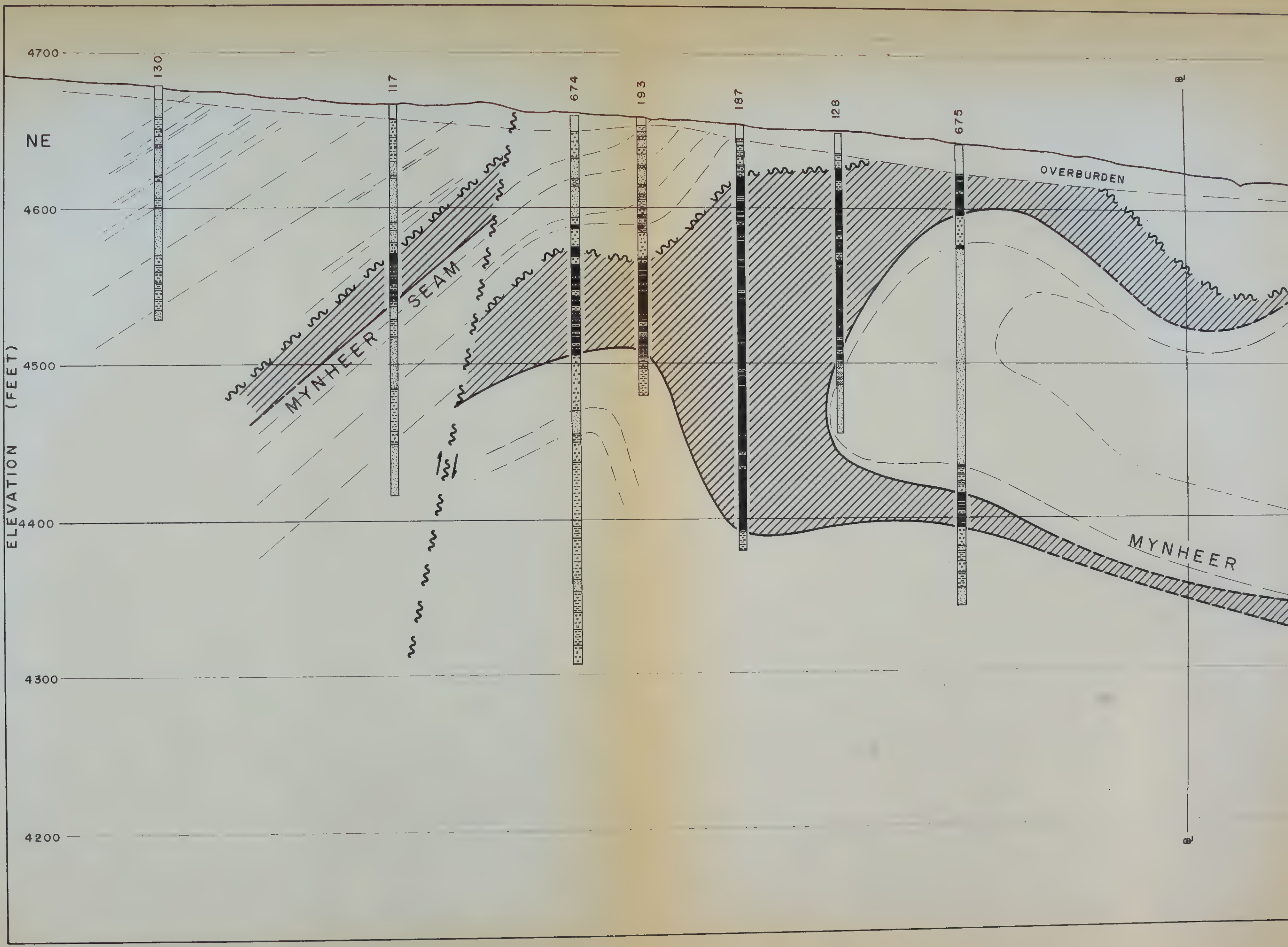


STRUCTURAL GEOLOGY
of the
LUSCAR-STERCO MYNHEER A ZONE
COAL VALLEY, ALBERTA

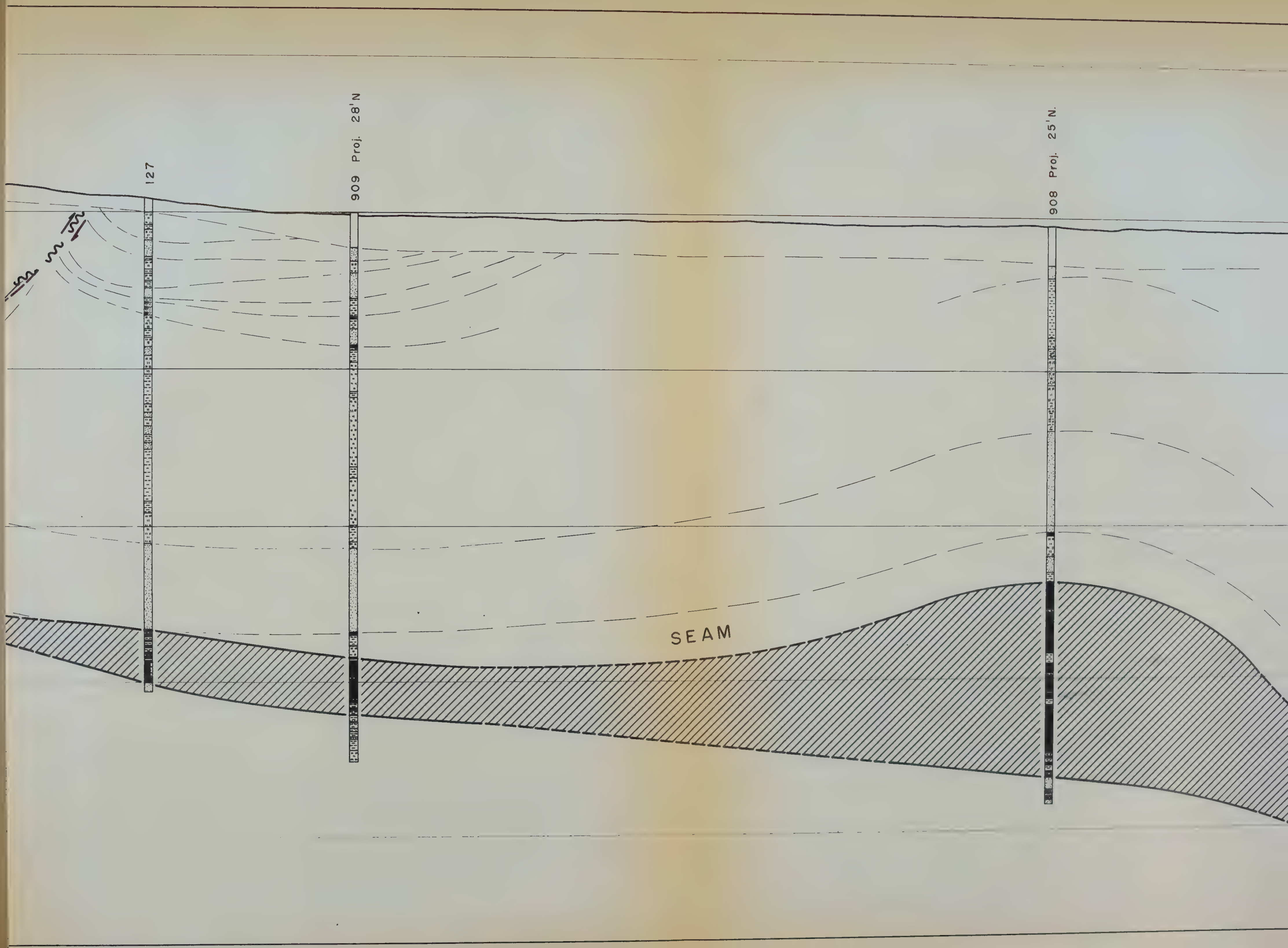
FIGURE 9:
CROSS-SECTION 112+00
FACING SOUTHEAST

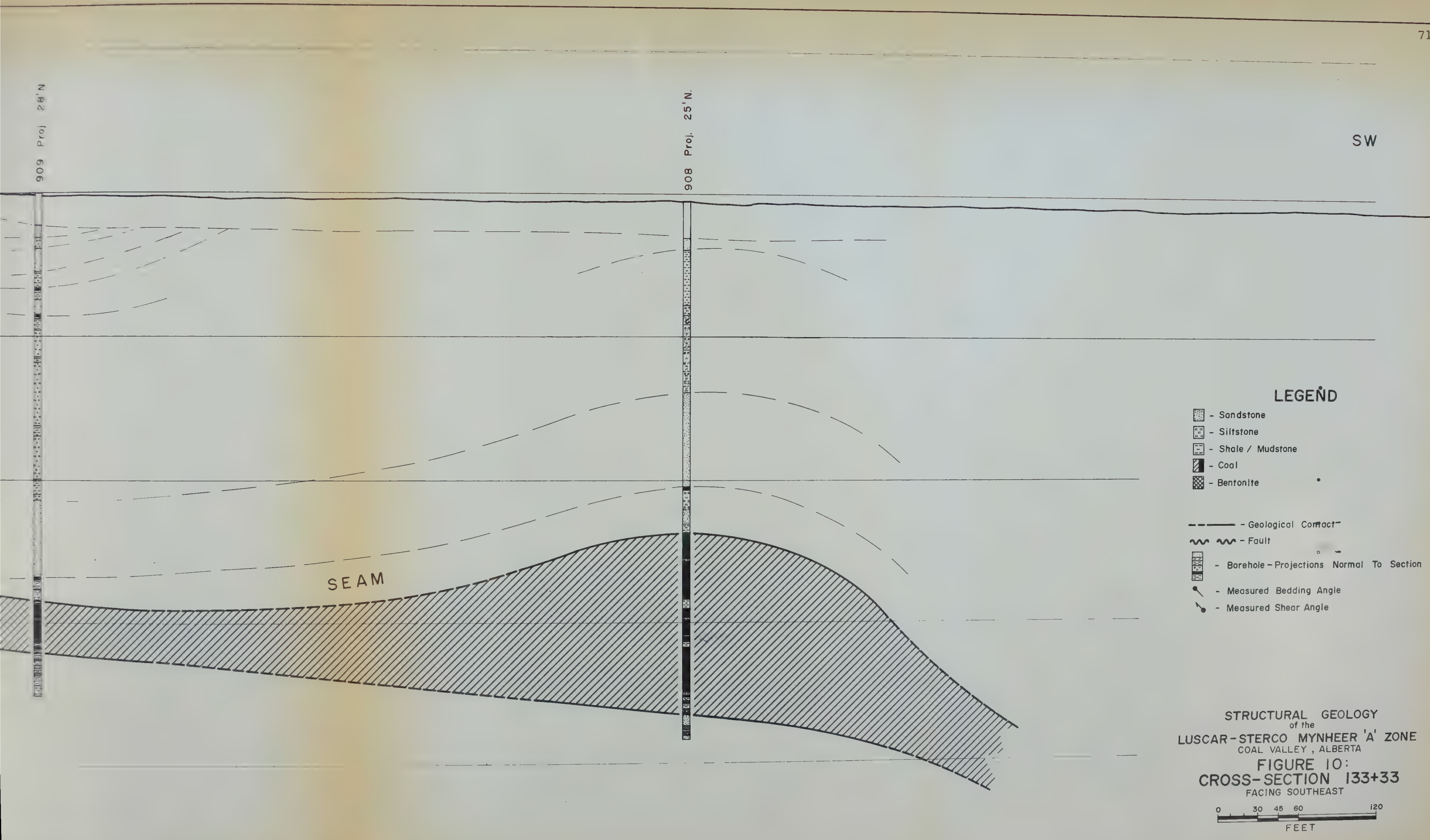


STRUCTURAL GEOLOGY
of the
LUSCAR-STERCO MYNHEER A ZONE
COAL VALLEY, ALBERTA
FIGURE 9:
CROSS-SECTION 112+00
FACING SOUTHEAST



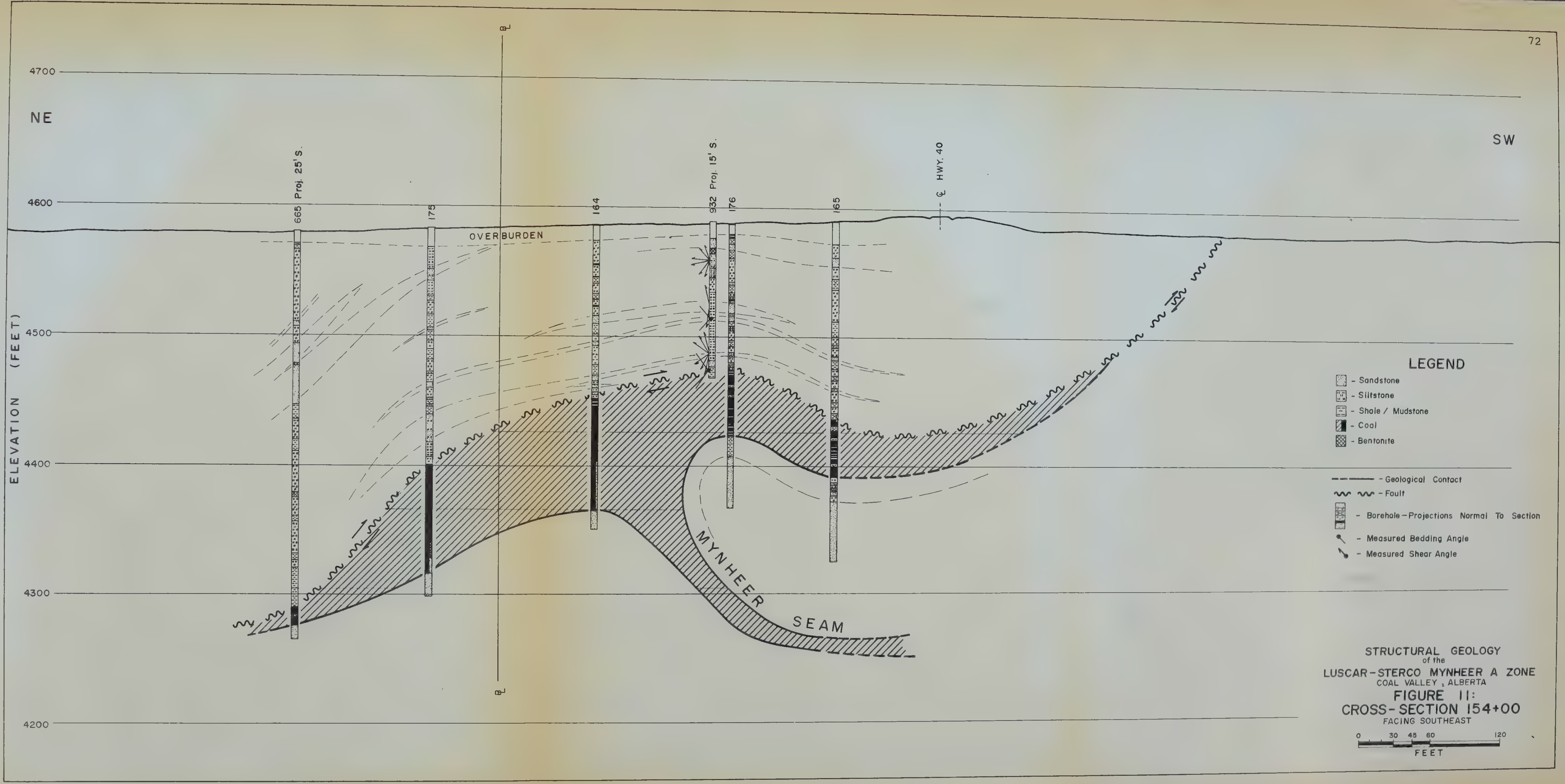
NE
ELEVATION (FEET)
4700
4600
4500
4400
4300
4200
130
117
674
193
187
128
675
B'
OVERBURDEN
MYNHEER SEAM
MYNHEER


127
909 Proj. 28'N
908 Proj. 25'N.
SEAM

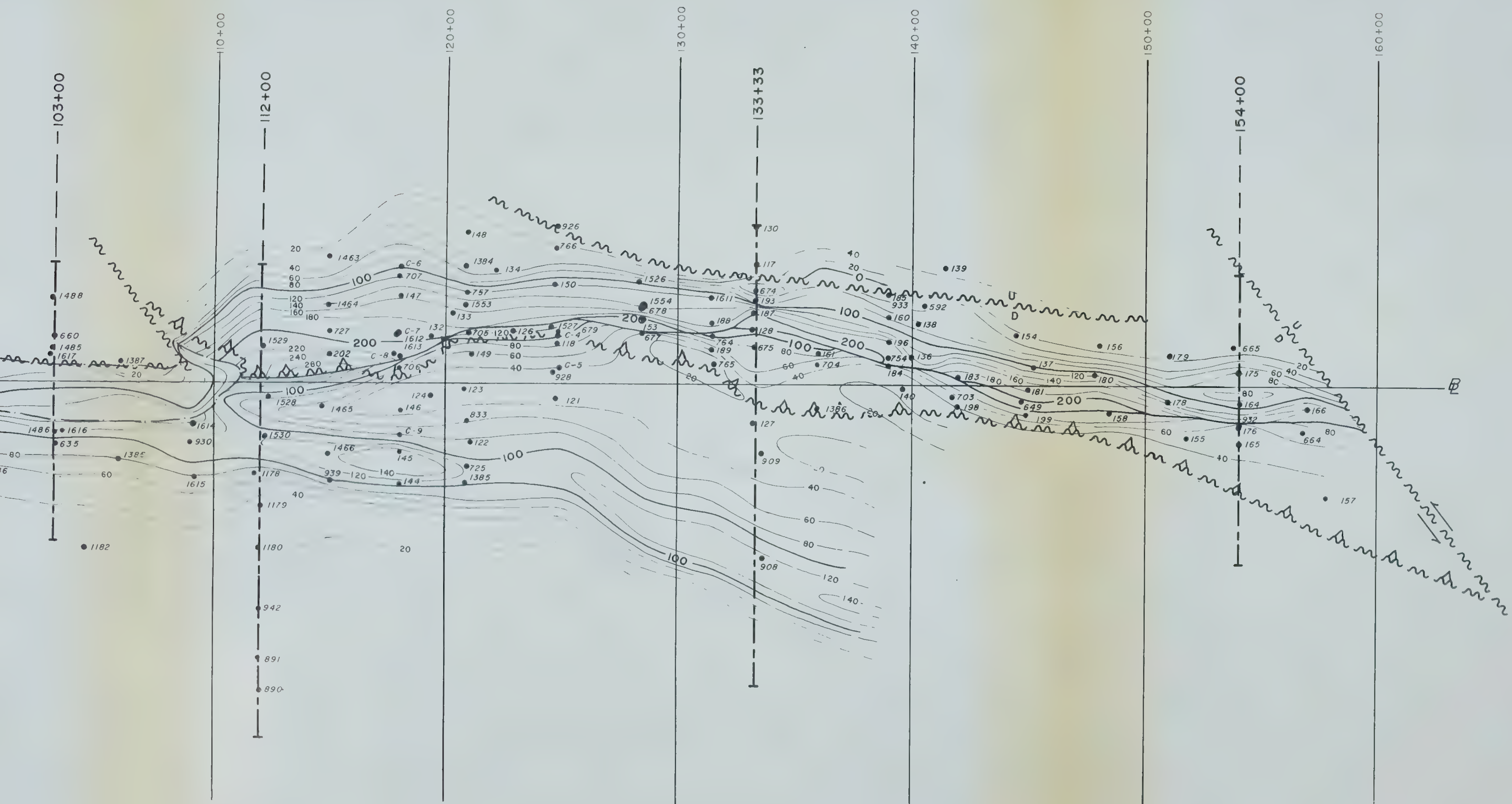


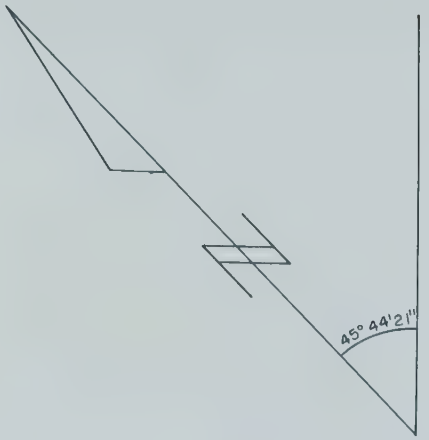
STRUCTURAL GEOLOGY
of the
LUSCAR-STERCO MYNHEER 'A' ZONE
COAL VALLEY, ALBERTA

FIGURE 10:
CROSS-SECTION 133+33
FACING SOUTHEAST



STRUCTURAL GEOLOGY
of the
LUSCAR-STERCO MYNHEER A ZONE
COAL VALLEY, ALBERTA
FIGURE 11:
CROSS-SECTION 154+00
FACING SOUTHEAST





LEGEND

1196 • - BOREHOLE

- EXCAVATION LIMIT

U D - FAULT (NORMAL, TRANSVERSE)

- THRUST FAULT (TEETH DOWN DIP)

- CROSS SECTION

FIGURE 14:

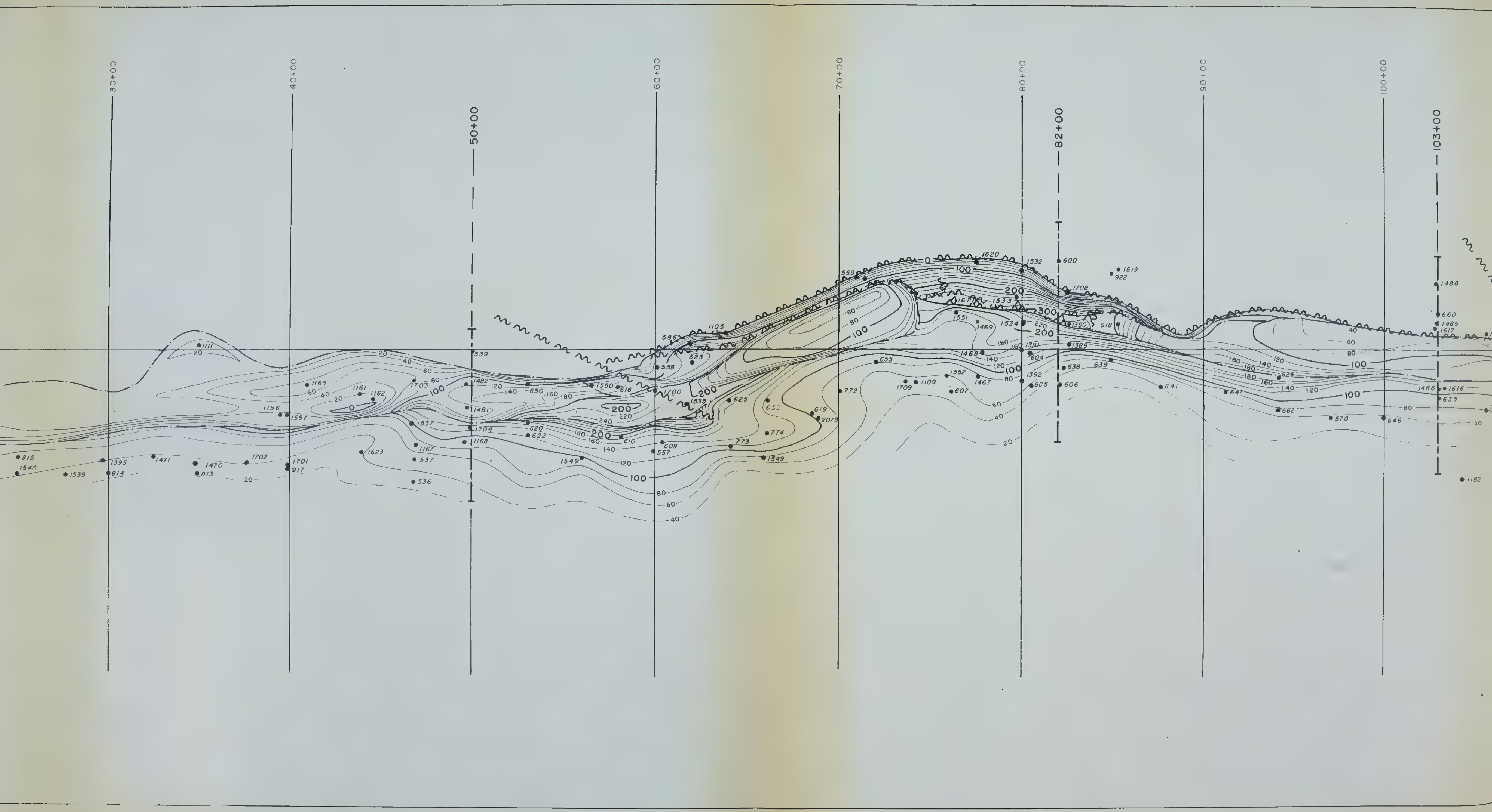
STRUCTURAL GEOLOGY
of the
LUSCAR-STERCO MYNHEER A ZONE
COAL VALLEY, ALBERTA

COAL POD ISOPACH MAP

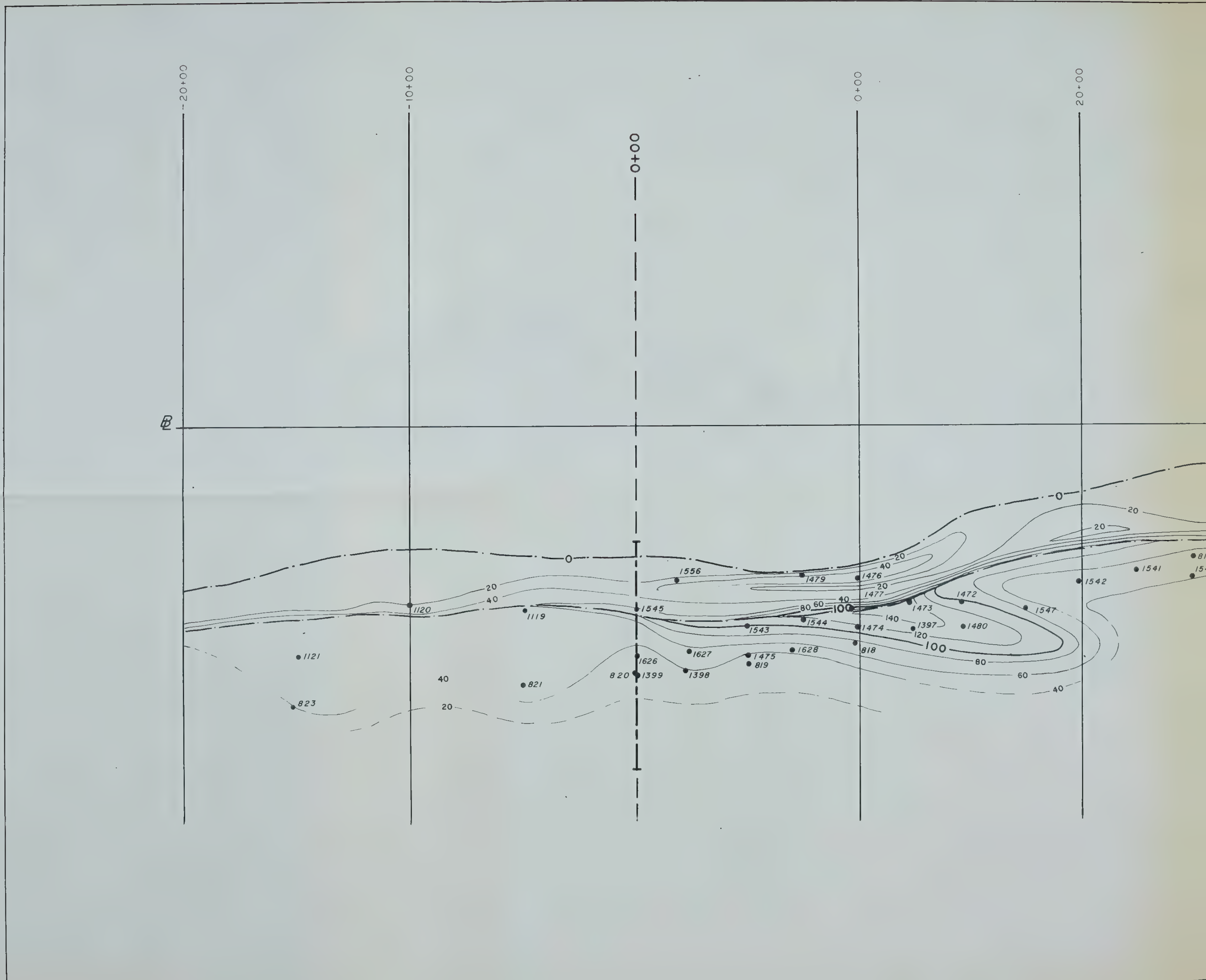
CONTOUR INTERVAL 20ft

SCALE 1" = 400'

0 400 800



30+00
40+00
50+00
60+00
70+00
80+00
82+00
90+00
100+00
103+00



-20+00
-10+00
0+00
10+00
20+00
0+00
BL
0
20
40
60
80
100
120
140
1556
1479
1476
1477
1545
1544
1543
1474
1473
1472
1397
1480
1547
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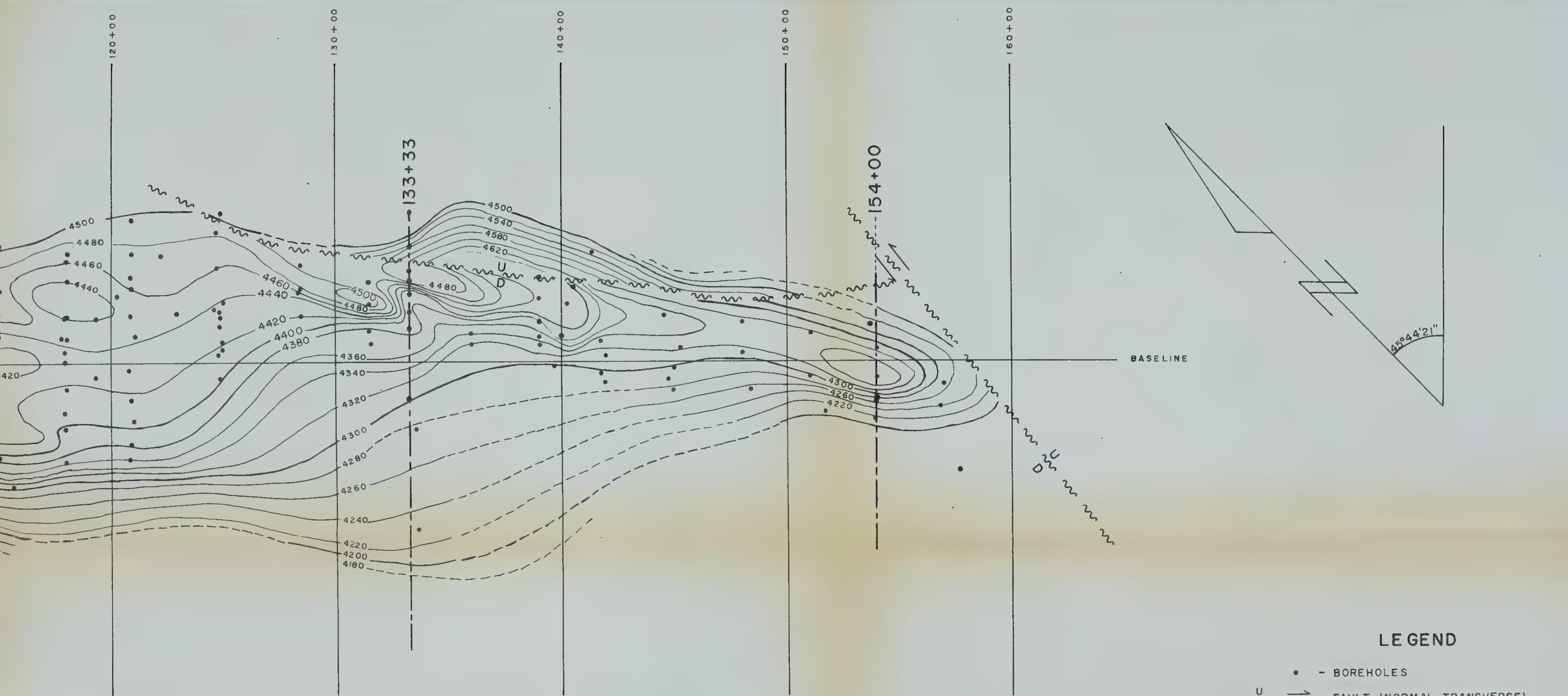
1399
1398
821
823



LEGEND

- • - BOREHOLES
- FAULT (NORMAL, TRANSVERSE)
- THRUST FAULT (TEETH DOWN DIP)
- EXCAVATION LIMIT
- CROSS SECTION

FIGURE 12:

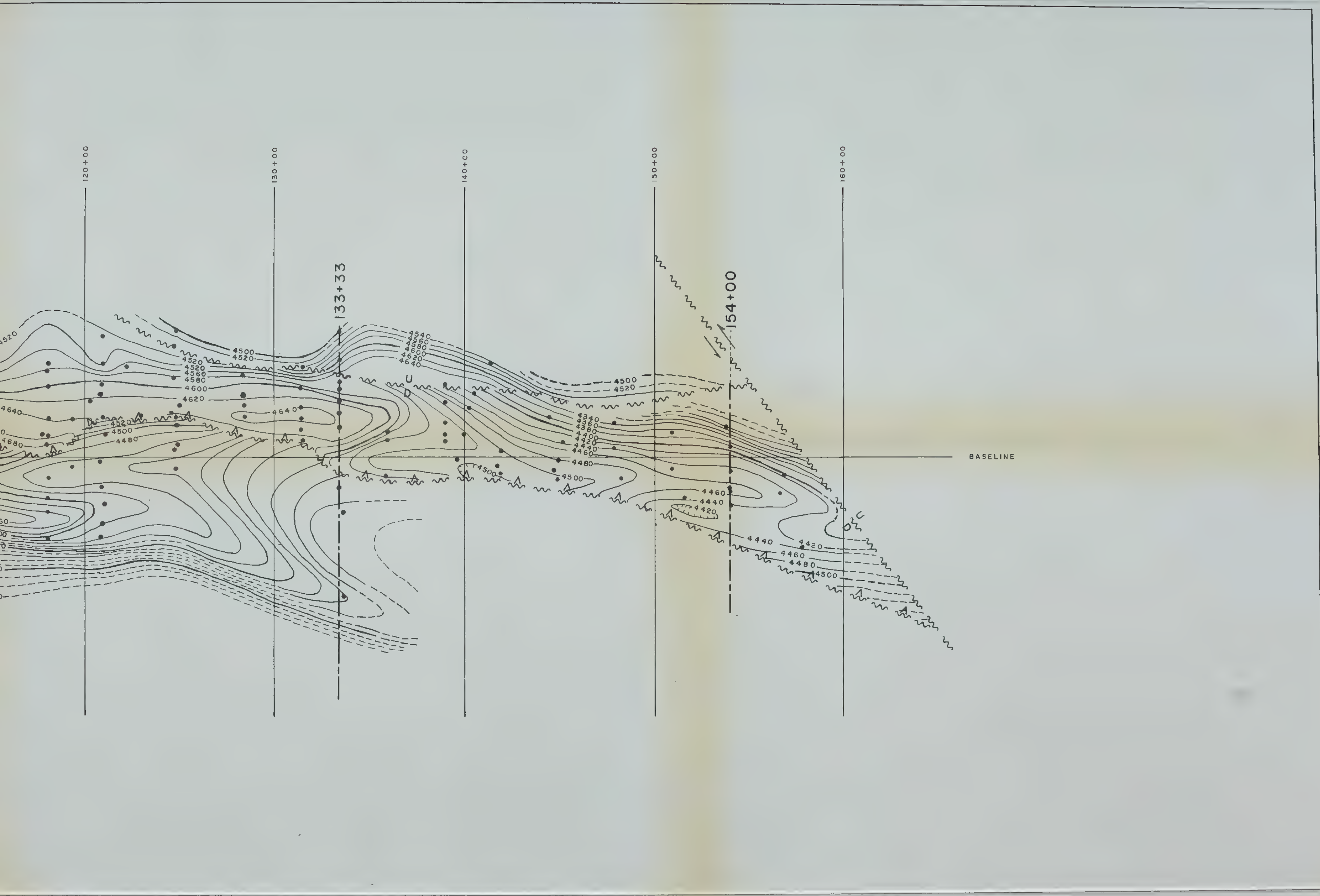
STRUCTURAL GEOLOGY
of the
LUSCAR-STERCO MYNHEER 'A' ZONE
COAL VALLEY, ALBERTA

STRUCTURE CONTOUR MAP

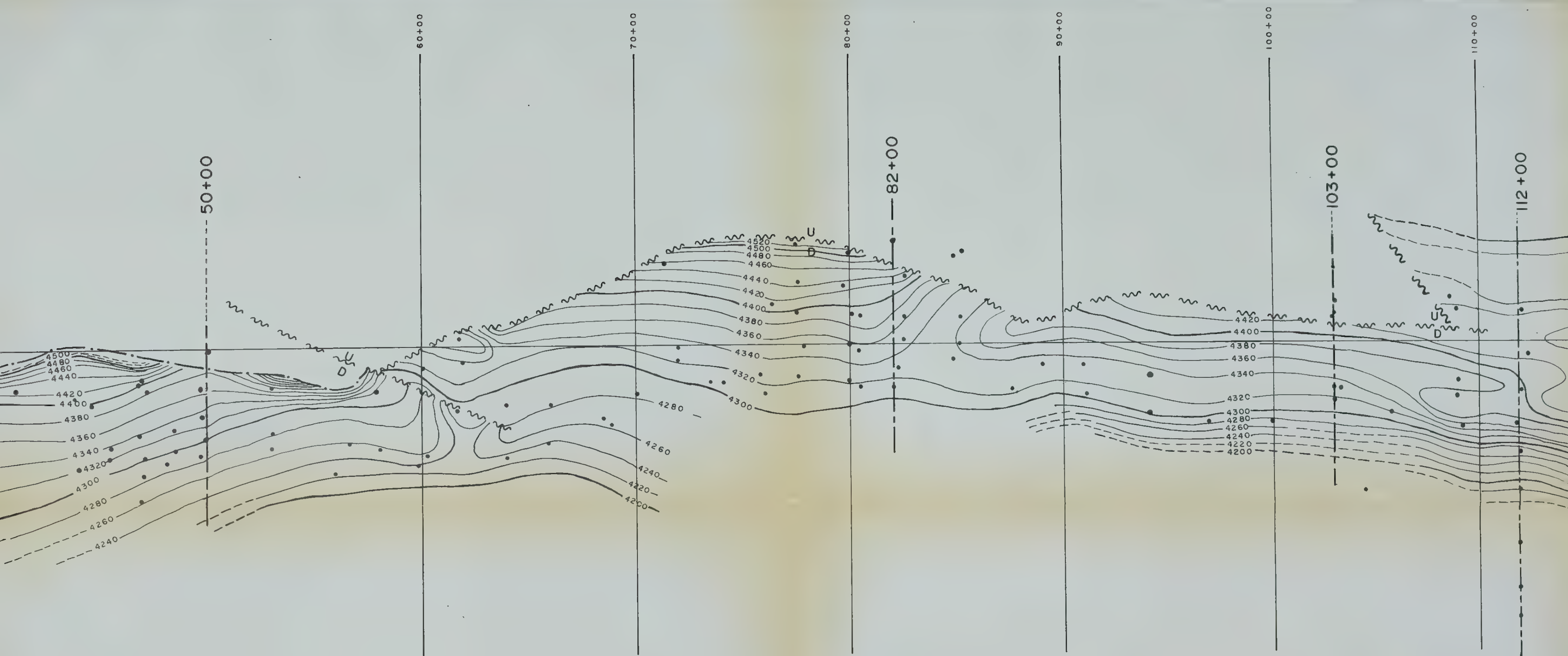
CONTOUR INTERVAL 20ft.
DATUM SEA LEVEL

SCALE 1"= 400'

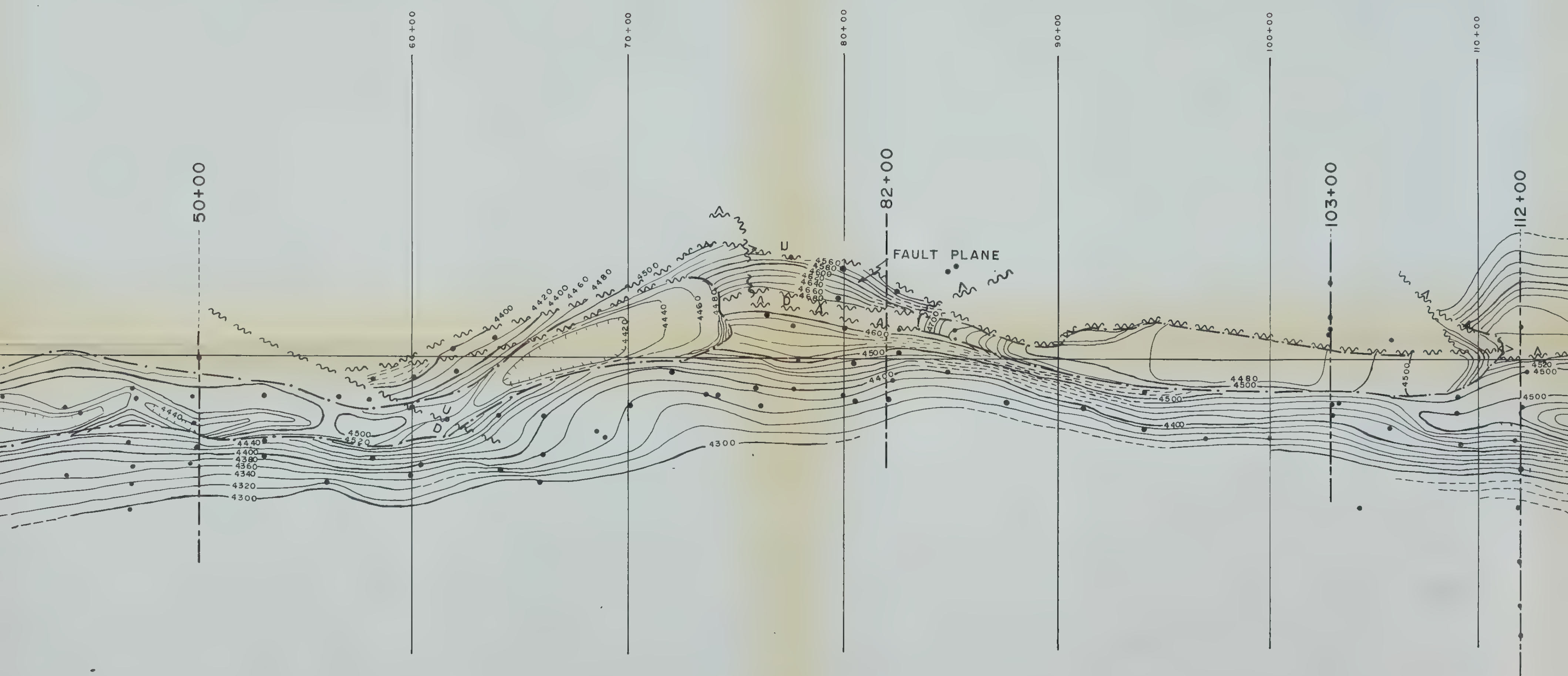
0 400 800



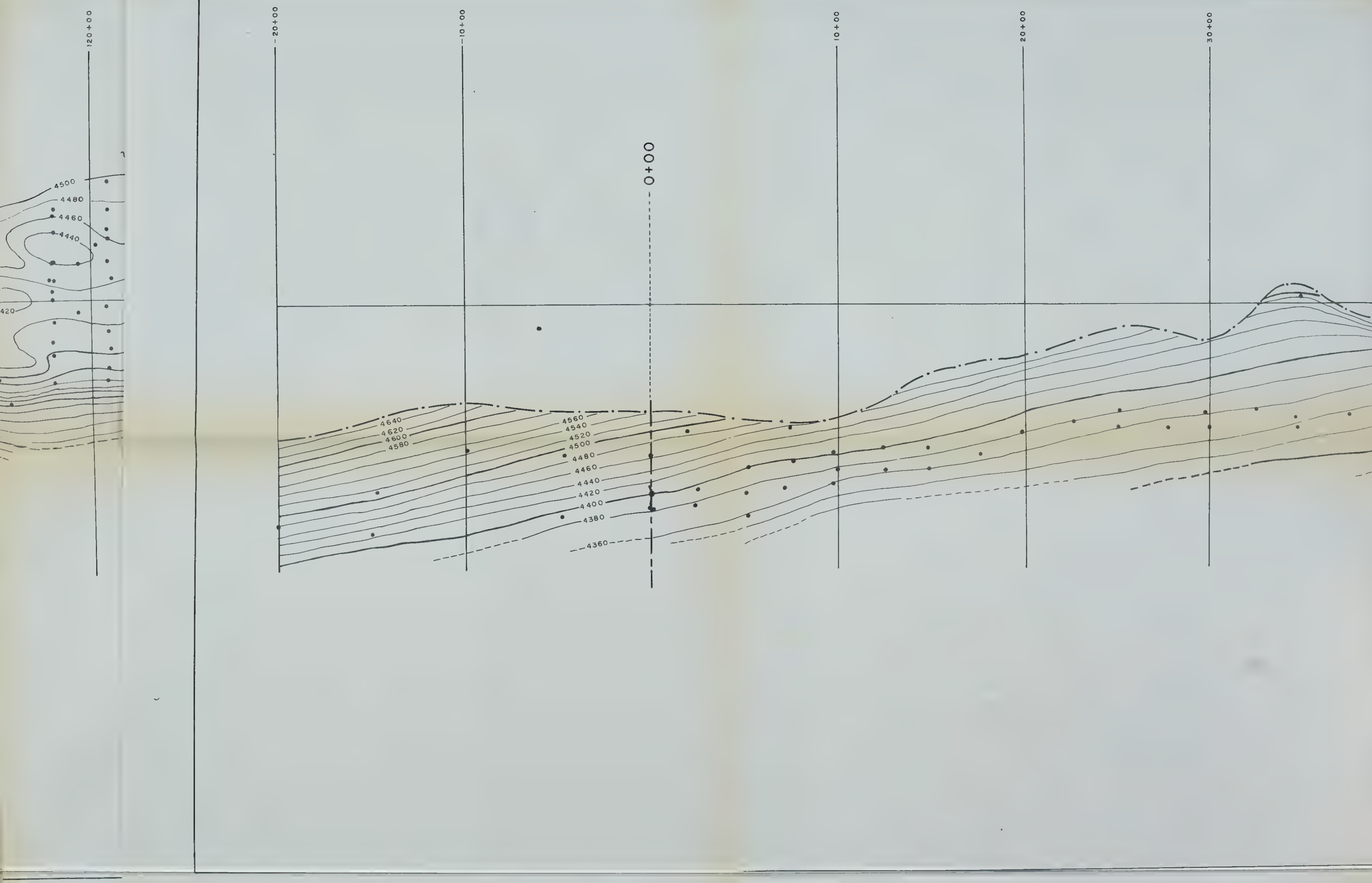
120+00
130+00
133+33
140+00
150+00
154+00
160+00
BASELINE
4500
4520
4540
4560
4580
4600
4620
4640
4480
4460
4440
4420
U
D



B: STRUCTURE CONTOURS ON BOTTOM OF COAL POD



A: STRUCTURE CONTOURS ON TOP OF COAL POD



120+00
-20+00
-10+00
0+00
10+00
20+00
30+00
4500
4480
4460
4440
420
4640
4620
4600
4580
4560
4540
4520
4500
4480
4460
4440
4420
4400
4380
4360


120+00
-20+00
-10+00
0+00
10+00
20+00
30+00
4660
4640
4620
4620
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4420
4400
4380
4360

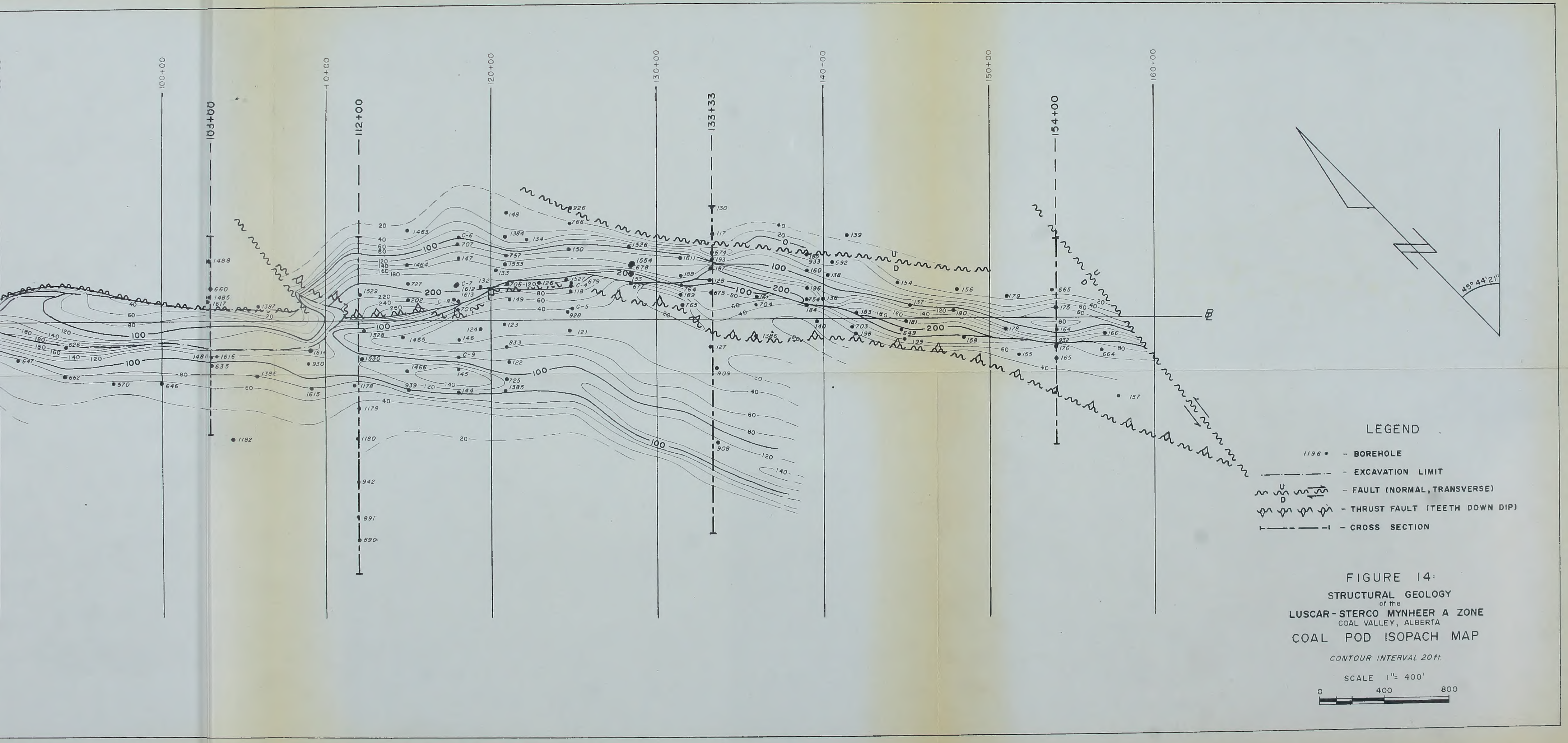
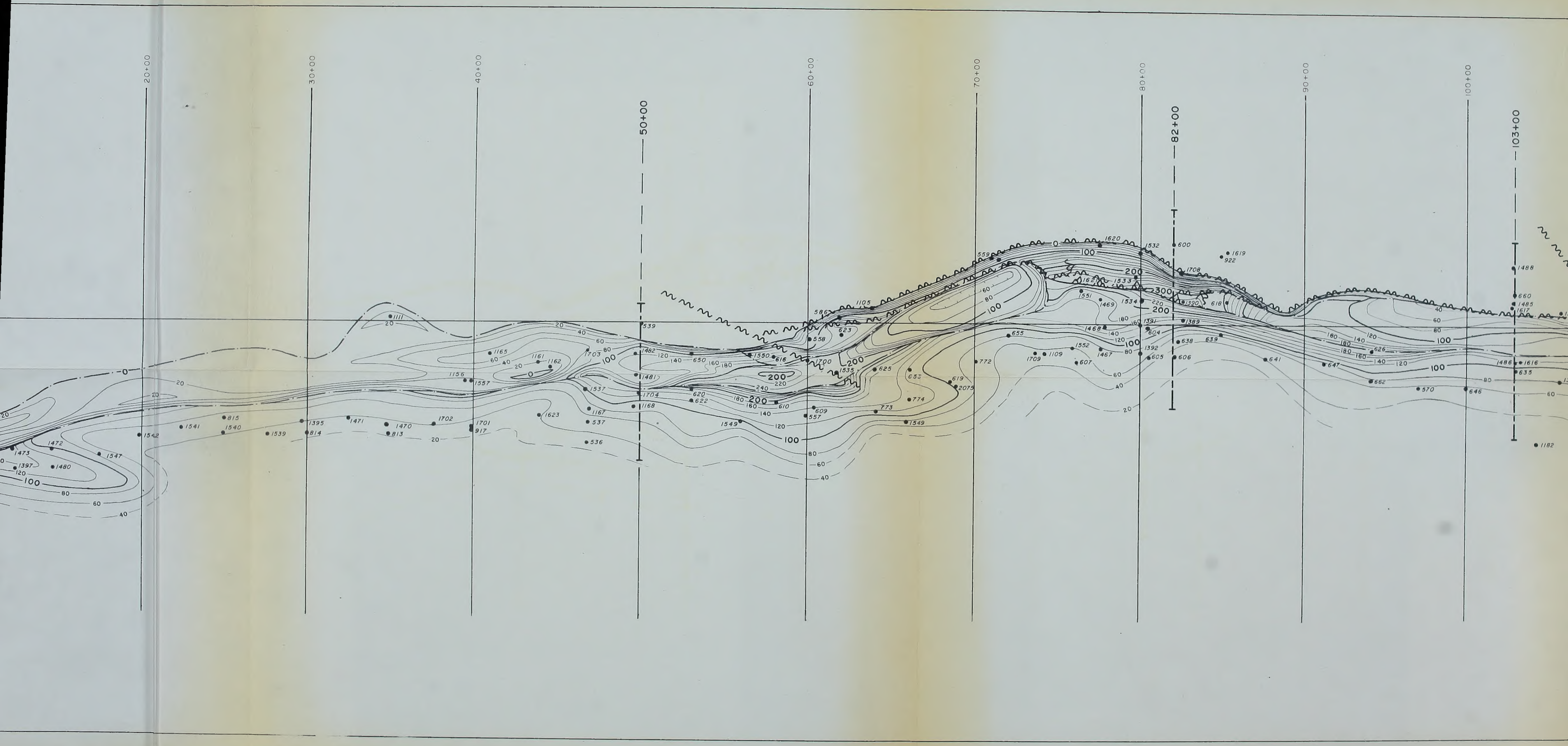
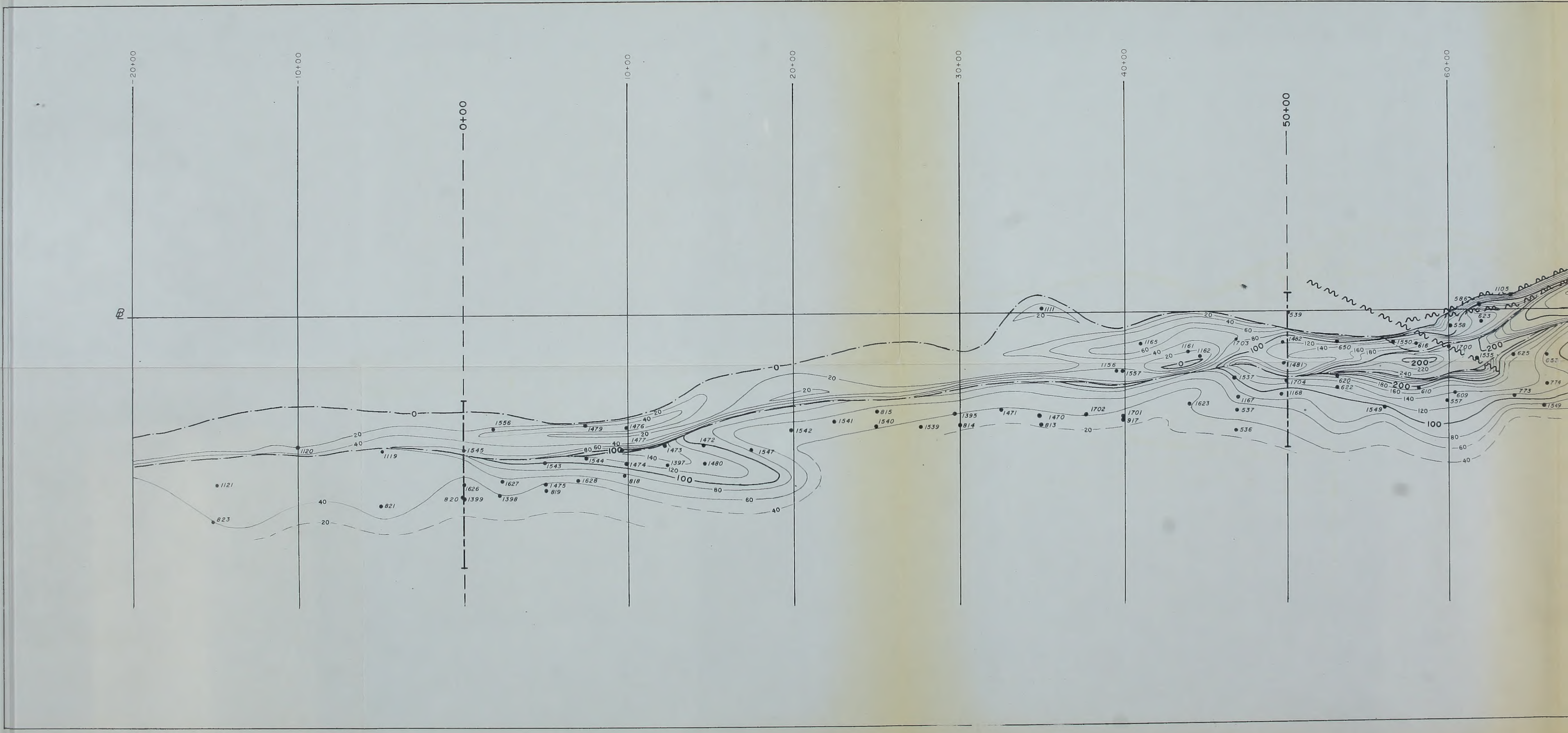


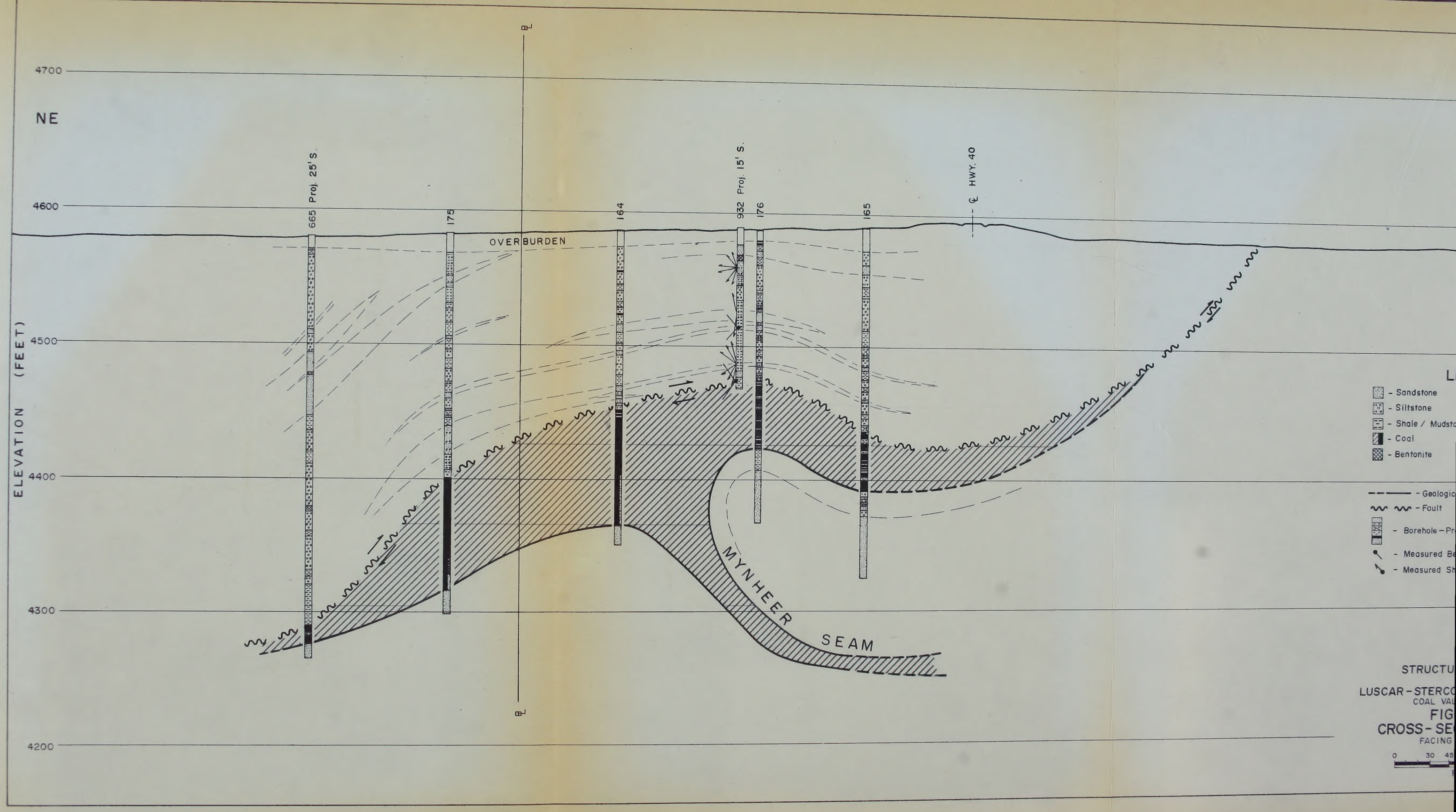
FIGURE 14:
STRUCTURAL GEOLOGY
of the
LUSCAR - STERCO MYNHEER A ZONE
COAL VALLEY, ALBERTA
COAL POD ISOPACH MAP



20+00
30+00
40+00
50+00
60+00
70+00
80+00
82+00
90+00
100+00
103+00



-20+00
-10+00
0+00
10+00
20+00
30+00
40+00
50+00
60+00


ELEVATION (FEET)
4700
4600
4500
4400
4300
4200
NE
665 Proj. 25' S.
175
164
932 Proj. 15' S.
176
165
℄ HWY. 40
OVERBURDEN
MYNHEER SEAM
- Sandstone
- Siltstone
- Shale / Mudsto
- Coal
- Bentonite
- Geologic
- Fault
- Borehole - Pr
- Measured Be
- Measured Sh
STRUCTU
LUSCAR - STERCO
COAL VAL
FIG
CROSS - SE
FACING
0
30
45